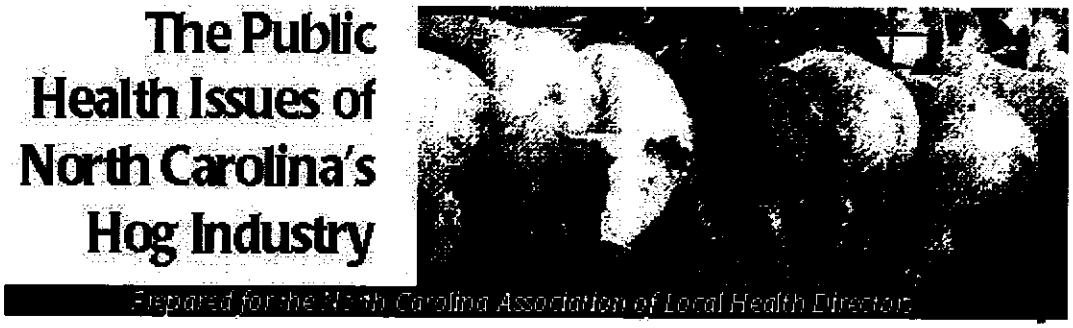

Human Health Issues Associated with the Hog Industry

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Introduction

The swine population in North Carolina increased from approximately 2.5 million in 1990 to 10 million in 1998 and went from being raised on small independent farms to large intensive livestock contract operations. More hog intensive livestock operations (ILOs) result in more hog waste concentrated in a specific area. The waste is first stored in a confinement or growing house and then flushed and pumped into a nearby lagoon. The wastewater is periodically sprayed onto fields. Odors from such operations emanate from the confinement houses, the lagoons, and the spraying fields. Generally, the odors coming from the confinement houses and some phases of the spraying operations are the most intense. The growth of the hog population is concentrated in the southeastern part of the state. Two counties, Duplin and Sampson, account for approximately four million hogs or forty percent of the state's hog population and rank as the number one and two hog producing counties in the United States. The sudden growth of swine intensive livestock operations (ILOs) resulted in increased community complaints particularly about the problems associated with hog waste. Citizens were concerned with the industry's impact on the health of nearby residents, the environment, and the overall quality of life in the community.

Neighbors of hog intensive livestock operations, especially those affected by the odors, have been especially vociferous at public meetings (Schiffman, 1998). Concerns about human health include exposure to odors; waste; resulting flies; poor air quality; and the contamination of drinking water supplies. Environmental concerns include groundwater and surface water contamination, air pollution, and the overloading of nutrients and heavy metals on soils where hog waste is applied. Citizens comment before boards of health that their health is negatively impacted and their quality of life is degraded. Dr. Hervy B. Kornegay, Sr., MD, who serves as Chair of the Duplin County Board of Health, reports, "Such a correlation is medically difficult to prove and document, but it is certainly perceived." (Kornegay, 1998) Citizen concerns in the counties with major swine livestock operations, such as Duplin and Sampson counties, and major processing plants, as in Bladen County, include increased truck traffic especially at night, dead animals sitting in the hot sun awaiting pick-up and then exploding when dumped in the hauling truck, and resulting animal waste on the road from alive and dead hogs. Community health issues associated with the hog industry embody concerns about the workforce, and pre-existing health problems they have, who are

drawn to the area due to employment opportunities at the operations and the slaughterhouses. There is a high turnover rate of the workforce (Cooper, 1997). Many who work at such facilities are immigrant workers who suffer high rates of tuberculosis and HIV infection, especially among young Hispanics (Kornegay, 1998).

Researchers are challenged to determine what the impacts of the hog industry are, especially as it pertains to human health. Few studies have been conducted to determine the health effects for residents living near swine intensive livestock operations (ILOs). Most research has focused on the more direct consequences that workers face in the confinement houses and processing plants. Two recent preliminary studies have looked at the impact on the physical and mental health of nearby residents. These studies need to be conducted with larger study populations to validate their preliminary findings. Additionally, research is needed to see if some of the anecdotal findings as reported in the media, such as the effect of hog odors on asthmatics, can be substantiated through rigorous health studies. This paper summarizes the issues pertinent to human health that are raised by people and pigs living in proximity to each other. Section One includes research findings and information related to air issues. This section contains specific concerns for the health of workers employed in the hog industry; the effect on the physical and mental health of neighbors to hog ILOs; and some preliminary concerns for asthmatics living in proximity to such operations. Section Two covers the groundwater issues associated with hog ILOs and the related health concerns of consuming water contaminated with nitrates. Section Three includes some of the surface water issues that appear to be related to high nutrient waters. Section Four contains information about infectious disease concerns for workers and neighbors to such hog operations. In Section Five the findings are summarized and recommendations made.

Section One: Air Quality

Livestock air emissions and the resulting odors are not new to eastern North Carolina. The countryside is dotted with hog, turkey, and poultry operations. In 1998, the state ranked number 2 in the nation in hog production, number 1 in turkeys, and number 4 in poultry. The number 1 and 2 hog producing counties in the nation, Duplin and Sampson counties, are also number 1 and 2 in the nation in turkey production. The two counties have a combined hog population of 4 million and 22.4 million turkeys (NC Dept. of Agri., 1998). Although all livestock operations generate smell, odors are most intense from the large hog intensive livestock operations. These operations are wet-based waste management systems with water used to flush the waste periodically from the growing houses. Poultry and turkey are dry-based waste management systems. The dry litter helps absorb some of the volatile organic compounds (VOCs) which result in less VOCs transported to the atmosphere.

1.1 Physical Health Effects for Workers in Swine Intensive Livestock Operations

Thousands of gases and/or particles are emitted from swine intensive livestock operations. These gaseous emissions are of particular concern for workers at such facilities. The health issues are well-documented (Donham, et al., '84, '85, '90, '93). They include: scratchy throat, morning phlegm, cough, burning eyes, wheezing, shortness of breath and chronic bronchitis. Additionally, workers in swine confinement houses are found to experience increased organic dust syndrome (Rylander et al., 1990). The primary gases and particles emitted by such operations are: ammonia, carbon monoxide and dioxide, hydrogen sulfide, methane, dust, organic dust, and endotoxins (Donham et al., 1985). Bacteria are present in the hog dust that consists mostly of hog epithelium. Endotoxins are the primary lipid component of the outer membrane of Gram-negative bacteria (Donham, 1986) and are the cause of chronic respiratory symptoms of workers employed in swine containment facilities. The odors are generated by a mixture of fresh and decomposing feces, urine, feed, the animals themselves, and dead hog carcasses.

Worker health issues have become more pronounced as hog production has increased in scale and moved to large, closed confinement growing houses, a trend which started in the 1960s in the United States (Donham, 1993). Compared with the older conventional livestock houses, confinement buildings are more enclosed and tightly constructed, which results in the trapping and recirculation of air. The ILOs house a larger number of animals per house than in the older hog houses and typically confine from 800-1200 in each house in North Carolina. New operations constructed in the West, such as Utah, by North Carolina integrators can house from 3000-4000 hogs in one structure. The animals are grown in small tightly packed areas within the house, where they are in constant contact with each other. One of the reasons for housing the hogs in multiple structures is when there is a disease outbreak, it can hopefully be contained in the one structure and not spread to all the animals at the ILO.

Hogs are kept in such structures 24 hours a day for the duration of their life, approximately six months, until they are ready for shipment to a slaughterhouse. Such buildings are usually heated and ventilated and animal waste is disposed of through a mechanized system. Animals stand on cement floors with openings. The excrement of the animal is pushed through the openings after the animal lays on top of it. The waste sits in storage areas below the animals and is emptied periodically- sometimes only every few days. The air environments of such closed hog growing structures with up to 1200 animals located in a single house are more contaminated than in houses which are more open and where less animals are kept.

Poor air quality in the confinement structures is of concern to worker exposure, but likewise to animal health and productivity. Some growers may be more inclined to make structural changes to the houses knowing that their hogs will produce more efficiently. Swine grow faster and are therefor more productive in confinement structures with better quality air (Donham, 1990, 1993). Dr. Donham stated, "Advising this fact to a swine producer may be the most expedient way to create environmental improvement that would help the person as well as the animals in the building."(Donham, 1993)

The first study of worker health issues resulting from employment in hog confinement houses was published in 1977 by a team of Iowa researchers (Rylander et al., 1989). Workers employed in such hog growing structures are exposed to both dust and gases which can be harmful to human health (Donham, 1990). Of the off gases in such facilities, ammonia is most likely to exceed the Threshold Limit Value. Most gases emitted are in small amounts, well below Threshold Limit Values. The mixture of over 400 gaseous compounds (Schiffman, 1996) represents a potential health threat for the 400,000 workers employed in swine confinement buildings. The gases can on occasion reach acutely toxic levels during manure agitation, ventilation failure, or the malfunction of heating units.

The nature of the gases and their intensity depend on multiple factors: the age of the animals, time of year, management practices, ventilation, how and what animals are fed, how well the facility is managed, and most importantly how the animal waste is handled including frequency of wash (Donham, 1993). William Smith, the Health Director in Robeson County, North Carolina, described the importance of the waste options available to hog producers and the consequent impact on workers who spend hours a day in such structures but also the odor impact on nearby residents living downwind. Mr. Smith said a facility that does not frequently flush the waste out of the building is like a large family where everyone uses the same toilet that is only flushed once a day, or even every few days. He compared this to a family whose members flush the toilet after each use. An equivalent swine waste management system, developed by such companies as Awash, involves a continuous flush of hog feces and urine into a waste lagoon and thereby cuts down on odors and gases that might build up in the confinement houses.

When studying worker health response to employment in hog ILOs, it was found that cough and phlegm were the most common symptoms and were experienced by 12-55% of the workers (Donham, 1990) depending on the particular ILO facility studied. Chest tightness, coughing, nasal and eye symptoms can occur within 30 minutes of entering the confinement structures but typically require two or more hours of exposure. Symptoms usually disappear after one to two days, however, they can persist for long-term employees. Worker symptoms in response to employment in swine growing houses are more frequent and severe among smokers and by those who work in the larger swine operations. Health effects are also greater among those with pre-existing respiratory problems, such as hay fever and bronchitis, and among those with heart trouble or allergies.

A small percentage of the cases of workers experiencing symptoms are thought to be specific allergic-mediated illnesses, such as asthma, and the rest fall into chronic inflammatory reactions. In a Swedish study, hog farmers indicated reported symptoms that included throat irritation (28%), eye irritation (25%), and nose irritation (25%) (Rylander et al., 1990). Of particular concern is worker exposure in the confinement houses to hydrogen sulfide. At high concentrations the gas has toxic properties and can result in sudden collapse and associated respiratory paralysis and pulmonary edema and even death. Research conducted by an international team of scientists involved in

clinical and epidemiological investigations of 2000 workers in five countries found symptoms of acute and chronic airway inflammation were common in addition to organic dust toxic syndrome.

In addition to immediate symptoms, workers can experience delayed reactions up to six-hours after working in the confinement buildings. This is true after exposure to especially dusty operations, involving the handling, moving or sorting of animals. Called organic dust toxic syndrome (ODTS), symptoms can include fever, malaise, muscle aches and pains, headache, cough, and tightness of chest. Some moderate pulmonary function changes were found. (Rylander et al., 1989)

Chronic health effects, such as bronchitis, is experienced by 25% of all swine confinement workers (Donham, 1993). Chronic bronchitis is found more than twice as frequently in workers in confinement buildings as those who work in conventional swine growing units. Symptoms related to chronic bronchitis include chronic cough, excess production of phlegm, and sometimes chronic wheezing.

Some workers, once removed from working in the confinement buildings, are still symptomatic two or more years later. However, most, especially nonsmokers, become asymptomatic after a few months. Long-term lung damage may be occurring as seen in lower flow rates. Pulmonary function decreases during the workday. The severity of chronic bronchitis increases with workers with a longer history in confinement units. The air in the confinement units does not cause asthma, however, exposure to the dust particles exacerbates asthmatic symptoms. Although the health effects for workers in swine ILOs has been well documented, the impact on neighbors has only been studied recently and so is less well understood.

1.2 Physical Health Effects for Neighbors to Hog ILOs

Neighbors of hog intensive operations have reacted to the noxious and unaesthetic air quality generated by the ammonia and hydrogen sulfide associated with the waste. Given the low concentrations of the gases, some believed that there was no significant risk to health and the odors represented more of a degradation of quality of life (Swinker, 1998) than a present health threat, even though those two can be hard to separate out. Swinker points out that it is difficult to distinguish health effects possibly caused by swine ILOs versus other human or agricultural activities. All possible contributing factors should be considered before describing and ascribing a causal relationship associated with swine ILOs. Further research is needed to determine the exact impact of the industry. A preliminary Iowa study described below (Thu et al., 1997), however, found that there are health effects associated with living adjacent to such operations.

A recently completed preliminary health study in Iowa (Thu et al., 1997) suggested that there were physical health effects for neighbors of hog intensive livestock operations. Ammonia, dust, and endotoxin were found in air samples taken downwind of a large-scale swine operation. The health study indicated that symptoms for near-by residents

are similar to those found for workers in the confinement houses only less severe and less frequent (Thu et al., 1997). Residents in Iowa who lived within two miles of a 4000 sow production facility were interviewed in their homes. This facility was one of the largest sow operations in Iowa. Neighbors were asked to complete a survey concerning their physical and mental health status. They were also asked open-ended questions about their impressions of the impacts of the hog industry on the community and quality of life. Standard socio-demographic information was collected.

The particular operation was selected for study based on its size and the fact that some neighbors had expressed environmental and health concerns. Responses of residents living near the operation were then compared to a control group. The selection of a controversial operation for study may have biased the results. The study of neighbors of the largest sow operation in the state would give results that may represent the worse case scenario. Results indicate that residents living within two-miles of the operation reported significantly higher rates of four types of respiratory tract problems, which represent toxic or inflammatory effects. In 14 of 18 symptoms the study population reported higher frequencies than the control group. The symptoms more frequently reported are those that are extensively experienced by swine confinement workers. Thu and Donham's 1997 study found increased symptoms in four interconnected symptom clusters. The symptoms correlated well with those reported in the open-ended questions queried earlier in the interviews.

CLUSTER	SYMPTOMS
Cluster One	Sputum, Cough, Breath Shortness, Chest Tightness, Wheezing
Cluster Two	Nausea, Dizziness, Weakness, Fainting
Cluster Three	Headaches and Plugged Ears
Cluster Four	Runny Nose, Scratchy Throat, Burning Eyes

The first cluster shows interrelated symptoms that indicate inflammation of the bronchi and bronchioles, or chronic bronchitis and hyperactive airways. The particular kind of bronchitis experienced is often associated with environmental exposures. Figure 1 below shows that for most symptoms, the neighbors of the sow operation indicated more health problems than the control group. In the first cluster of inter-related symptoms, increased sputum was most pronounced in the study group.

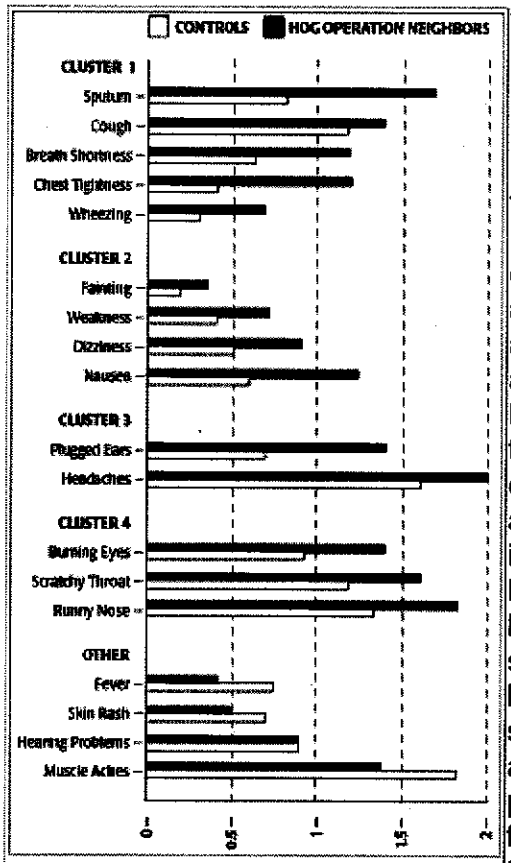


Fig.1. Frequency of physical symptoms experienced by rural residents
(comparison of mean scores, 0=Never, 4=Very Often).

The inter-related symptoms included in the second cluster are those that are commonly found in employees of swine operations. Residents living near the studied operation reported significantly higher rates for nausea, dizziness, weakness, and fainting, than the control group. Further study is needed to determine the effect of long-term exposure to lower than toxic levels of Endotoxins and hydrogen sulfide. The component gases associated with the air emissions from swine ILOs are individually well below federal standards. However, over 400 compounds have been found in the air, manure, and lagoons on hog farms. The compounds include acids, alcohols, aldehydes, amides, amines, aromatics, esters, ethers, inorganic gases, hydrocarbons, halogenated hydrocarbons, ketones, nitriles, nitrogen heterocycles, phenols, sulfides, mercaptans, and steroids (Schiffman, 1996). The compounds found both in North Carolina and elsewhere tended to be standard volatile organic compounds (VOCs) as associated previously with animal waste. Sixty percent of the compounds found in NC were not found elsewhere. More VOCs were found in NC than reported in other states. This can be explained by: the sensitivity of the gas chromatography testing methods used, temperature conditions in North Carolina, and chemical sprays mixed with the air and lagoon samples were included in the test.

Federal and state standards are only set for one gas at a time and standards have only been determined for a few hundred gases. One hundred and five air toxics are covered by state regulations and 189 by federal regulations, with an overlap between the two of approximately 85 air toxins. Researchers, such as Dr. Lori Todd and Dr. Susan Schiffman, suggest that a synergistic effect of the component parts working together may be of importance and further study is indicated.

The third symptom cluster, which includes headaches and plugged ears, is also often noted by workers in the swine industry. These symptoms are frequently associated with chronic sinusitis, and are found in approximately one-fourth of all active swine producers (Donham, 1993). The final cluster of symptoms noted, which showed the least significance, included symptoms such as: burning eyes, runny nose and scratchy throat. Among swine confinement workers, these symptoms are related to mucous membrane irritation caused by irritation from gases and particulates inside the swine confinement buildings. Nasal irritation has been shown to reduce respiratory volume (Warren, et al., 1994).

The Iowa study found residents to be no more or less depressed or anxious than the control group. These findings may have been influenced by the fact that someone was interviewing the respondents which can bias toward the under reporting of mental health effects.

One of the findings of the Iowa study was, regardless of whether respondents were experiencing any physical health symptoms, that the presence of the swine facility was creating social and political problems and divisions within the community. Respondents saw the facility as a violation of core rural values of what it means to be a "good neighbor". Such values include principles of egalitarian relationships, reciprocal exchanges of neighbors helping each other in times of need, mutual respect, and sharing of information (Thu et al., 1997). Neighbors felt that the facility threatened their sense of control over their land, homes, families, and quality of life. The concerns raised by neighbors encompassed more than physical and mental health issues but were intertwined with personal, environmental, economic, and social health matters. The hog industry is seen to impact both the quality of life and way of life for rural residents living near swine intensive livestock operations. These findings are consistent with citizen testimonials at county meetings in North Carolina. In Duplin County a citizen lamented that marshalls were needed at Board of Health meetings to assure there was no violence among attendees with opposing views.

1.3 Hog ILO Odors

Odors associated with swine ILOs emanate from the confinement houses where the animals are kept, the waste storage areas including the lagoons, and the land application area. The liquid wastewater in the lagoons is periodically sprayed onto fields via spraying systems that eject the wastewater as much as 100 yards. The odors result from a combination of fresh and decomposing feces, urine, and feed. Of these, the more offensive odors emanate from the decomposition of the feces. Emissions from livestock manure include volatile organic acids, alcohols, aldehydes, amines, fixed gases, carbonyls, esters, sulfides, disulfides, mercaptans, and nitrogen heterocycles.

The inhalation of volatile organic compounds (VOCs) causes smell sensations in humans. There are four primary ways in which these odors can affect human health:

- the VOCs can produce toxicological effects;
- the odorant compounds can cause irritations in the eye, nose, and throat;
- the VOCs can stimulate sensory nerves that can cause potentially harmful health effects; and
- the exposure to perceived unpleasant odors can stimulate negative cognitive and emotional responses based on previous experiences with such odors (Schiffman, 1998).

Levels of VOCs in breath have been measured and correlate with the individual's personal air. The body is subjected to some burden as a result of non-occupational exposure to VOCs (Raymer et al., 1991). Low concentrations of multiple VOCs can

result in health consequences that a single low-level VOC would not cause (Schiffman, 1998). The volatile organic compounds, which cause odors, can be absorbed directly via gas exchange in the lungs. These VOCs can reach blood and adipose tissue. For hours afterwards, people can still detect the odor as it is expelled from their bodies.

1.3.1 North Carolina Studies of Mental Health Effect

The psychological impact on neighbors of swine intensive livestock operations living in odor concentrated areas was documented by Dr. Susan Schiffman, a medical psychologist with the Duke University Department of Psychiatry (Schiffman et al., 1995). In this preliminary study of North Carolina residents, 44 people living downwind and in the odor affected area of swine operations were compared with a control group of rural people not so affected. The study of mood was considered important not only to better understand the psychological impacts but additionally because negative mood can depress the body's immune response. Unpleasant odors can thus influence physical health. Brain structures broadly involved in smell can affect immune responses. Some studies suggest that sensory stimulation of the limbic forebrain, hypothalamus, and other odor projection brain areas can directly alter immune status (Schiffman et al., 1995).

In Schiffman's study a significant difference was found (at $p < .0001$). The experimental subjects that lived within the hog odor affected area expressed significantly more tension, depression, anger, less vigor, more fatigue, and more confusion.

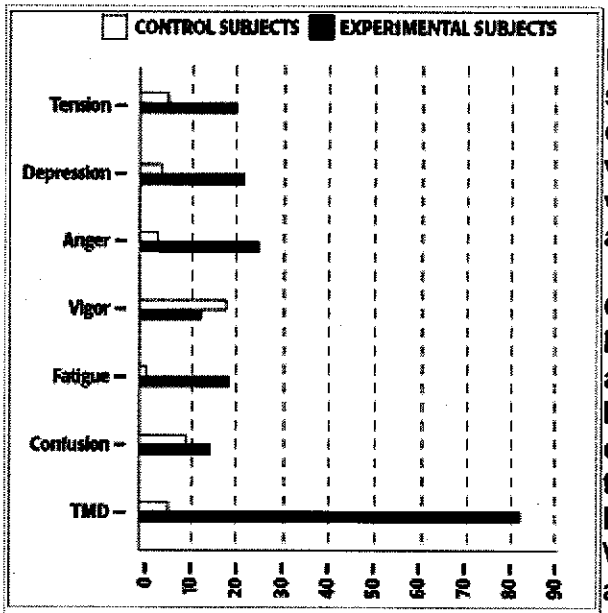


Fig. 2. Mean POMS scores of each factor and the total mood disturbance score (TMD) for experimental and control subjects.

Experimental males had significantly higher scores for anger and confusion than experimental females or control men and women. Scores for experimental females were significantly higher than control males and females.

Odors can have a lingering effect in the body. Volatile organic compounds (VOCs) are absorbed directly by the body into the bloodstream and fatty tissues by way of gas exchange in the lungs. Once absorbed these odorants are slowly released from the bloodstream via air expired from the body. When expired, the olfactory receptors are activated. Some of the compounds found in the waste plume, when absorbed in the body, can be transmitted to the brain through the nasal route (Monath et al., 1983). Some people, who are already experiencing other olfactory problems, may be more sensitive to the smell. Odors affect both the quality of outdoor and indoor air. Clothing, curtains, and building materials

absorb the smell. Over time, the odor molecules are slowly released resulting in a prolonged effect from the odor even once the plume has passed over.

The effect of exposure to odors on respiratory responses has not been a subject of research interest. In part, this is due to the fact that animal studies indicate that changes in breathing patterns may require far higher chemical concentrations than are needed for detection. Recent work, however, shows that in human subjects, as opposed to animal studies, that the sensitivity of respiratory measures may not lag far behind that of perceptual measures of irritation (Warren et al., 1994).

People respond differently to the hog waste smell depending on their association with the odor. Some swine operators say the smell does not bother them and that they associate it with providing for their family. Many come from multi-generational hog farming families and see the operation and its smells as a way of life. At public hearings, owners of hog operations often say the odor smells like money to them.

But for the neighbors, often those not directly economically benefiting from the activity, they may associate the smell with unpleasant thoughts and lack of control. Strong livestock odors in one's home are considered inappropriate by most. One community activist tells the story of a birthday party for her child, when one of the children came to her and asked if she could please go home because the stink was so bad.

For others, the smell may result in environmental concerns, fear of loss of use and value of property, or an interference with the use of ones property. Some neighbors in Duplin County report being surrounded by hog confinement buildings that result in the odors from such operations being regularly present. Other neighbors report a frequency of one out of every three days that the odor affects their home with the early morning and evening as the time when the smell is usually strongest and most regular. Others may consider the smell to be a taboo odor and something that they shouldn't have to endure (Schiffman et al., 1995). As the public has learned more about the health consequences of breathing in the malodorous smell of second hand cigarette smoke, heightened consciousness can be applied to concerns about living in areas with regular exposure to the odors and air emissions from the hog operations.

Some people living in proximity to hog ILOs find conditions practicably unlivable. In a lawsuit, Parker v. Barefoot (No. COA97-713) against a Johnston County hog operation holding approximately 2,880 hogs in four hog houses and one open pit lagoon, 27 neighbors reported that fumes from the hog ILO were so noxious that at times it burned their eyes and noses, making it difficult for them to see and breathe. The stench from the lagoon was described as 'unbearable'. Plaintiffs sought injunctive and monetary relief alleging that the swine facility constituted a nuisance. In this case, the NC Court of Appeals on July 7, 1998 overturned the lower court's decision and granted plaintiffs' right to a new trial. In the earlier trial, the plaintiffs had submitted a written request for instructions to the jury that the law did not recognize as a defense to a claim of nuisance that defendants used the best technical knowledge or "state-of-the-art" technology available at the time to avoid or alleviate the nuisance. The trial court denied this

request. Judge Howard E. Manning in Johnston County Superior Court entered the judgment in favor of the defendants on August 30, 1997. The appellate decision now focuses juries to the validity of neighbor's complaints of a nuisance when an operation is found to be so offensive as to have an intolerable impact on its neighbors. The offense can be great enough to affect neighbors ability to enjoy their homes. In a July 11, 1998 editorial of the *News & Observer*, the paper calls attention to the need for the state and local governments to set odor standards to protect the health and well being of neighbors of such facilities. In the fall of 1998, the NC Environmental Management Commission began work to regulate odors from hog operations.

In an odor study of NC residents (Schiffman, 1998) who did not live near agricultural operations, 68% of the subjects who were classified as 'More Sensitive' and 62% who were considered 'Less Sensitive' reported that exposure to animal odors would make them ill if exposed for 30 minutes or more.

Multiple factors can play a role in the changed mood of people exposed to odors from nearby swine operations. These factors include: the unpleasantness of the sensory quality of the odor; the intermittent nature of the stimulus; learned aversions to the odor; potential neural stimulation of immune responses via direct neural connections between odor censers in the brain and lymphoid tissue; direct physical effects from molecules in the plume including nasal and respiratory irritation; possible chemosensory disorders; and unpleasant thoughts associated with the odor (Schiffman et al., 1995).

The intermittent character of hog odors affecting neighboring properties is also an unpleasant factor. Although no one would want such strong odors to be constant, the fact that they come and go draws attention to the offense (Aitken et al., 1991). The odorant molecules associated with hog farms can cause nasal and respiratory irritation. The irritation of the nasal area can result in an elevation of adrenaline, which stimulates feelings of anger and tension.

1.3.2 Differences Between Psychological Findings in the North Carolina and Iowa Study

The Schiffman study results in North Carolina of the psychological effect on neighbors of swine ILOs differed from the findings in the Thu/Donham study in Iowa. The Iowa study found little difference in depressive and anxiety symptoms between their respondents and the control group. The authors concluded that the study population was neither suffering from anxiety related nor depressive psychological symptoms. In the Iowa study, researchers interviewed all subjects in person, which may have biased people from admitting to psychological problems. In the North Carolina study, subjects completed a written survey on their own. Most importantly, they were asked to complete the survey during an odor incident. This may have increased their attention to the event and their consequent response.

The Iowa and North Carolina studies took different approaches in selecting their study populations. Dr. Schiffman studied residents that lived downwind of swine intensive

livestock operations and in the odor affected area. The Iowa study surveyed people who lived within a two-mile radius of a particular 4000 sow operation and did not limit themselves to subjects living in the odor-affected areas. The Iowa operation selected was one that had a history of community complaints. Schiffman chose people from multiple counties from across North Carolina. People living downwind and in the odor affected area of swine intensive operations experience the impacts of such operations differently from those that might live near-by but not necessarily affected by the odor (Schiffman et al., 1995).

1.4 Odors and the Effect on Asthmatics- A Potential Health Concern that Needs Researching

No research to date has focused specifically on the effect the exposure to air emissions from hog waste has on asthmatics. However, some reported anecdotal stories reveal that there is potentially a relationship and that further study is needed. People report that odor events trigger asthmatic episodes and cause severe reactions. Research does show that many odors, both those generally considered pleasant and offensive, can have an impact on asthmatics. Sir John Floyer first noted the relationship between exposure to certain odors and a response in asthmatics in 1698 in his classic, "A Treatise of the Asthma." Odors, both those generally associated positively, as in perfume, and negatively, as in waste or insecticides, have been found to cause asthmatic responses in some patients (Shim et al., 1986). Of 60 patients studied in Shim and Williams' research, 57 claimed a respiratory reaction to at least one odor. Of the particular odors that most frequently worsened asthma, the most common offender was insecticide (85%), then household cleaning agents (78%), cigarette smoke (75%), fresh paint smell (73%) and perfume and cologne (72%). The asthmatic response to odor is often severe. Of the 60 patients studied, 23 claimed that they had to make an emergency room visit, and 9 required hospitalization. Symptoms include shortness of breath, tightness of chest, wheezing, and cough.

Many clinicians seem to be unaware of the association between exposure to odors and an asthmatic response, however, most patients are aware of such a potential and have found ways to avoid the offending odors in their daily life (Shim et al., 1986). There has been an increase in the prevalence of asthma, especially among children under 18 years of age (Koren, 1995). Asthmatics are more sensitive to the effects from exposure to ozone, sulfur dioxide, particulate matter, and nitrogen dioxide. The increase in asthma rates is in part associated with air pollutants, including volatile organic compounds. One of the compounds found in hog odors is formaldehyde, HCHO, which can cause asthma-like symptoms. Further study needs to be conducted to determine if chronic exposures to both the gases and particulate matter can result in potential toxicity (Schiffman, 1998).

The response of asthmatics to certain odors is most commonly found in sensitive asthmatic patients and in those who are having difficulty controlling their disease. The asthmatic response to particular odors may result from reactions occurring in the bronchial mucosa. This response can be caused either by a direct irritant effect, from an

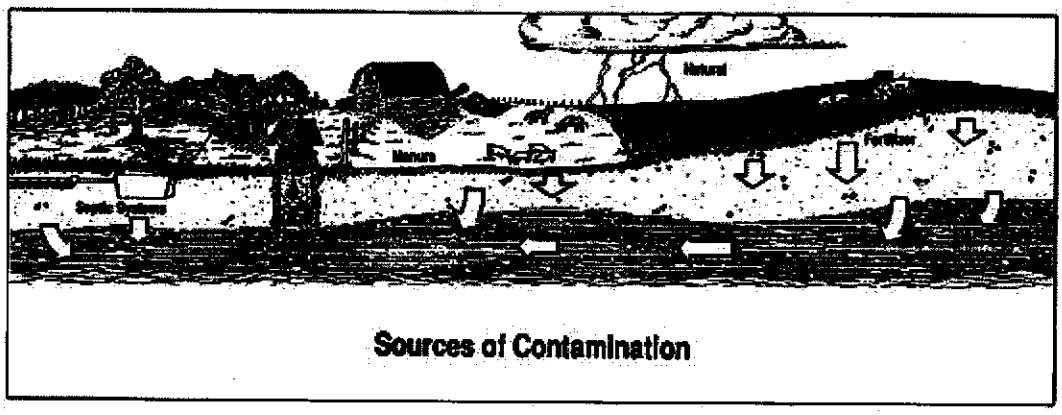
immunologic reaction with secondary chemical mediator release or from a local neural reflex (Shim et al., 1986). Further research is needed to determine if the emissions from hog ILOs are having any effect on the health of nearby asthmatic populations.

Section Two: Groundwater Contamination and Related Health Issues

Hog waste when stored in lagoons and later applied to fields can result in nutrients and pathogens ending up in nearby groundwater. Although nutrients, such as nitrogen and phosphorus, are essential to life, in excess they can send aquatic ecosystems into disorder, as seen in the Neuse River in the New Bern area. Too much nitrogen is also of concern regarding human health. Once ingested through nitrogen-contaminated water, in the human gut nitrate is reduced to nitrite and is absorbed into the blood (Swinker, 1998). Nitrite compromises the oxygen-carrying capacity of the blood. Likewise, pathogens found in the gut of hogs can be of concern if they come into human contact. North Carolina has focused extensive resources on testing for nitrogen in groundwater but has not concurrently investigated for possible coliform contamination.

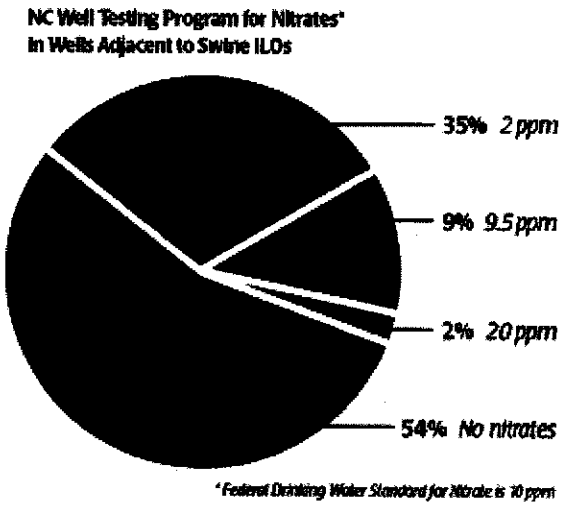
2.1 Nitrates and Drinking Water - A Concern for Human Health

Nitrates occur naturally in drinking water and in common vegetables, such as beets, celery, and lettuce. However, if the nitrates are present above a certain amount (10 ppm) they can be harmful to people who drink the water. Especially at risk are children under five, older people and those with suppressed immune systems. Nitrates can get into the drinking water from the overuse of chemical fertilizers and improper disposal of human and animal wastes. The nitrogen in the waste is converted to nitrates in the soil. The nitrates are highly soluble and move quickly and easily through soil, depending on soil type, and into groundwater and surface water. Once in the water, the nitrates can accumulate. In 1989 the NC Cooperative Extension Service conducted a one-year sampling program of rural drinking water supplies for nitrate-nitrogen, chloride, electrical conductivity and pH. Some of the samples were tested for pesticides. Of the over 9026 domestic wells tested, 3.2% exceeded the drinking water standard of 10 mg/L for nitrogen. Most of the contaminated wells were found to be poorly constructed and badly sited near areas of nutrient and pesticide application (Jennings et al., 1991).



Graphic Credit: Jody Kubitz, Institute of Water Research, Michigan State University

2.2 NC Well Testing Program



In 1996 NC Governor James Hunt called for a free drinking-water well testing program for nitrates in the wells of people living adjacent to hog operations. The testing was begun after several drinking water wells in Robeson County located near swine operations were found to have nitrate levels which greatly exceeded the federal drinking water standard. Dr. Kenneth Rudo, a toxicologist with the Occupational & Environmental Epidemiology Section, headed the program. By December of 1996, Dr. Rudo had tested 948 wells in 50 counties (Rudo, 1996). Approximately 9.4% of the wells tested showed levels of nitrate that were at or exceeded the nitrate drinking water standard of 10 ppm. In a 1998 memo to the new state Health Director, Dr. Dennis McBride, Dr. Rudo stated that continued testing of wells showed that approximately 10% of the wells tested had levels of nitrate that exceeded the federal standard (Rudo, 1998). Three wells in Robeson County had nitrate levels in the 70-100 ppm range. Once tested, if the water was found to exceed the drinking water standard, residents were notified of such. Testing for other possible contaminants, such as viruses, bacteria, or pesticides was not performed, nor were health studies conducted on the families who had been drinking the nitrate contaminated well water.

The following counties in North Carolina showed the highest levels of nitrates in the drinking water wells tested by the state.

Percent of wells with nitrate* levels > 2 ppm and >9.5 ppm respectively

COUNTY	TOTAL NUMBER OF SAMPLES TAKEN
Duplin (24%, 9.9%)	121
Edgecombe (34.7%, 0%)	75
Johnston (57.1%, 4.1%)	49
Robeson (39.5%, 10%)	210
Sampson (48.3%, 22.5%)	209

Potential sources of nitrate include hog waste, human waste, and fertilizers. Further study by the state is continuing to better determine the exact source of nitrate contamination. There is concern that with the explosive growth in swine operations in the last ten years that some of the problems with well-water contamination may still lie ahead, especially in Duplin and Sampson counties where the operations are concentrated. Some Duplin County residents have expressed concern about the amount of hog waste sprayed onto crops in the region's sandy soils. Other issues include that the depth of the lagoons is only slightly higher than the water table in the area, and the status of abandoned lagoons. These are of particular concern in rural areas where considerable poor people live and often depend on shallow wells for their drinking water.

2.3 Methemoglobin

An important health effect resulting from the consumption of high levels of nitrates is methemoglobinemia, more commonly known as Blue Baby Syndrome. The nitrate as it enters the body converts to nitrite which affects the hemoglobin that carries oxygen throughout the body. The hemoglobin converts to methemoglobin that does not transport oxygen as well. This results in less oxygen getting to vital tissues, and of special concern is the brain. Methemoglobinemia can produce cyanosis, dyspnea, lethargy, and coma (Swinker, 1998). If the problem is severe and not corrected, brain damage and even death can result. The syndrome was first identified in the mid-1940s and resulted in the standard for nitrate concentrations in drinking water of 10 mg/L.

Children in the first six months of life are particularly vulnerable to high nitrates because fetal hemoglobin is more reactive than adult hemoglobin. Also the flora found in the stomach of infants facilitates conversion of nitrate to nitrite. Others who are vulnerable include pregnant women, the elderly, and adults with immune deficiencies.

When nitrates are found in groundwater and the source of the contamination is animal waste or effluent from a septic tank, the well water should be additionally tested for other contaminates of concern, such as bacteria, viruses, and protozoa. If the source of nitrates is fertilizer, then the water should be tested for the presence of pesticides. When drinking water is contaminated with nitrates at levels above 10 ppm, other sources of drinking water, such as bottled water, need to be consumed. Sometimes the drilling of a deeper well into a non-contaminated water source may provide the best solution if financing is possible. However, if the nitrate contamination is widespread in a region, a public water system should be explored. Such an option is of course expensive.

2.4 Exposure to High Nitrates and Possible Link to Reproductive Health Difficulties

Research suggests that there may be a link between the consumption of nitrate-contaminated water and human health effects including increased risk of delivery of an infant with a central nervous system (CNS) malformation (Arbuckle et al., 1988) and reproductive problems (MMWR, 1996). Three women in Indiana who lived in close proximity to each other had miscarriages a total of six times within two years. The women were all drinking well water containing high levels of nitrate, which exceeded the federal standard of 10 ppm. The women lived near a hog operation that appeared to be the source of the nitrate contamination. Other women living nearby had given birth without any problems. The women having trouble with the miscarriages all lived the closest to the hog operation. Once the women switched to bottled water they were able to have fullterm healthy pregnancies. Although it was not proven that the source of the nitrates was the hog operation, the point is that the consumption of water contaminated with nitrates appeared to have affected pregnancy outcomes. The CDC recommends that anyone drinking water from a private well should have the water tested periodically (Meyer, 1996). Additionally, proper well construction with an emphasis on digging the wells deeper than 50 feet can alleviate many problems.

2.5 Waterborne Diseases and Well Water Consumption

Well water consumption is associated with several waterborne diseases. In the U.S. between 1991-92, 76% of the outbreaks of waterborne disease were connected to the drinking of well water (Moore et al., 1993) The total number of outbreaks has remained steady, however, new causative agents are being reported, which includes E coli 0157:H7 and Cryptosporidium (Swinker, 1998). Waterborne Cryptosporidiosis is of greatest concern when it enters municipal water treatment plants causing an outbreak of disease in the population that consumes the water. Such an outbreak occurred in Milwaukee, Wisconsin, when during the spring of 1993, over 403,000 were sickened with prolonged diarrheal illness, of which 4400 required hospitalization (CDC, 1994). Proper management of water supplies and surveillance are vital tools to the prevention of and early detection of such waterborne infectious diseases. Appropriate disposal of animal waste, including hog waste, is important in the control of Cryptosporidiosis and other infectious diseases.

2.5 Cancer and the Need for More Research

Several studies have shown an apparent increase in leukemia and brain tumors in children whose parents work in farming or in occupations where they are exposed to pesticides. A study was conducted of 323,292 children in Norway. The children were followed for a ten-year period. For children aged 0-14, there was a higher incidence of brain tumors associated with hog farming (Kristensen et al., 1996). The study, however, did not include individual exposure data and can be better used for hypothesis-generation than for drawing conclusions about risk of specific childhood cancers (Ross, 1996).

2.6 Community Concerns about Groundwater Contamination from Hog Operations- Difference Between Community Perception and Policies

Rural residents have expressed concern about the impact of hog intensive livestock operations and the impact on drinking water (Holtkamp et al., 1994). In Iowa, the number one hog producing state in the nation, 440 people completed a survey sent to residents of a two-county area in the southern part of the state. Respondents were asked to comment on their level of concern about the potential location of a new 1000 sow confinement near their home and the possible impact on groundwater.

Over 80% said they were 'somewhat' to 'seriously concerned' about the potential for nitrate contaminating their drinking water supplies. They indicated that even at a distance of five miles from a residence that they would be very concerned about the risk of contamination of their drinking water supplies. If such a facility was sited a half-mile from a residence, 77% of the respondees said they would be 'seriously concerned' about the potential for nitrate contamination. The survey results indicate that responses were sensitive to educational level. The lower the education attainment of the respondee, the lower the concern. Overall, rural residents surveyed did indicate a strong interest in environmental issues and 58% thought it was a 'top' or 'high' national priority. Sixty percent thought it was a 'top' or 'high' priority local political issue.

Section Three: Surface Water Health Issues - Associated Issues to the Hog Industry

Increased attention and concern over the hog industry's environmental and health impacts followed the dramatic rupture of the Onslow County hog waste lagoon during the summer of 1995. This resulted in the spillage of approximately 25 million gallons of hog waste onto neighboring fields, roads, and streams, and eventually into the New River. In addition to such dramatic crisis events, waste from hog ILOs gets into surface water when it is unintentionally or illegally discharged into ditches, wetlands, and directly into streams.

Public awareness of nitrogen enrichment and the resulting eutrophication of the Lower Neuse, Cape Fear, and Tar-Pamlico river basins and the Albemarle and Pamlico sounds has focused attention on the hog industry as a major source of such nutrients (Aneja et al., 1998). The nitrogen either directly enters such surface waters from other water sources, from the runoff from ILOs, and/or through the deposition of airborne nitrogen in the form of ammonia. Ammonia emissions in eastern North Carolina are almost solely associated with intensive livestock operations, especially from hog ILOs. Testing for airborne ammonia starting in 1980 in Sampson County has shown a dramatic increase, almost a four-fold increase since 1990, in the annual mean ammonium ion concentration in rainfall (Aneja et al., 1998). Such an increase correlates with the dramatic increase in the hog population in Sampson County during that same time period.

Other sources of increased nutrients include wastewater treatment plants resulting from population growth in the Piedmont, and the residential and commercial application of fertilizers throughout the river basins. Even elementary, middle, and high schools contribute to the problem. Although the state can clearly show that there is a problem with too much nitrogen, it is less clear as to what the different sources of nitrogen are and how much they contribute. The state has called for a 30 percent reduction (Brown, 1998) in the nitrogen load of 8.7 million pounds of nitrogen that reaches New Bern, NC. The reduction plan calls for the first mandatory comprehensive environmental requirements of agricultural operations. These cumulative water contamination problems resulting in high nutrient waters, although not clearly understood, appear to be associated with the preponderance of the dinoflaggelate, Pfiesteria. The relationship between water contamination, especially nutrients, and the presence of the micro-organism continues to be studied. This micro-organism over the years has been associated with some of the major fish kills, especially in the Neuse.

There is concern about related human illness caused by exposure to Pfiesteria. Some people who spend considerable time in the water experience skin lesions similar to those found on the fish caught in some fish kill areas. Local physicians in the area of New Bern, North Carolina have expressed concerns about the negative contribution of the hog industry on the health of their patients.

3.1 Physician Petition in Support of Hog Moratorium in Craven County

In February of 1997 seventy-five physicians of the medical staff of Craven Regional Medical Center signed a petitioning letter endorsing a one-year countywide moratorium on new and expanding hog operations for Craven County, located in eastern North Carolina. The petition was submitted at a public hearing of the Craven County Board of Commissioners. The petitioning letter read:

"We, the physicians of Craven, Jones and Pamlico counties, by our signatures on this letter, express our deepest concerns for the environment and citizens of our counties. We understand that the issues of industrial and agricultural waste disposal are complex and highly technical, while at the same time, political and intensely emotional.

Our role as physicians requires that we be vocal advocates for our patients' health and well being. We believe that the issues of agricultural and industrial waste disposal pose a health risk to our patient population. We therefore petition the Board to grant the moratorium, which will allow these areas of concern to be addressed more fully."

At the Craven County public hearing to discuss a county moratorium on new and expanded hog operations, Dr. Chris Delaney spoke in favor of such and presented slides of a man's legs with crusty sores. The sores had allegedly appeared after the man submerged his legs in the nearby Neuse River (Clabby, 1997). An increasing number of people who have had contact with the Neuse are experiencing similar skin lesions. Especially at risk are people whose livelihoods require that they spend considerable time on or in the water, such as professional underwater divers and commercial fishermen.

Dr. Peter Rowlett from Craven County in NC raised an additional issue during the public hearing. He stated that he would like to see North Carolina state health officials be more proactive (Clabby, 1997) in responding to some of the problems physicians are detecting in his area of the state. He stated that doctors routinely treat people with lesions with antibiotics with no effort made to establish the causative agent. He would like the state to establish a system where such lesions were cultured and sent to a state lab. Such a lab could assure identification of the lesion's origin and assist the state in its understanding of the cause and frequency of such.

3.2 Pfiesteria - A Potential Marker of Polluted Waters

Some medical reports indicate that humans who spend a lot of time on or in the water, such as commercial fishermen and underwater divers, are experiencing similar problems, including but not limited to open sores on their skin. Researchers at North Carolina State University studying the dinoflagellate, Pfiesteria, experienced both short term and long-term memory problems and balance difficulties after a heavy dosage exposure to the associated toxins. Since 1991, this organism has been found in the vicinity of more than 100 fish kills in the Neuse, New and Pamlico rivers (Clabby, 1997). What stimulates the dinoflaggelates' growth and activity is still not understood (Clabby, 1997). For five years, the controversy surrounding research and scientists' and policymakers' understanding of Pfiesteria has raked the state (Barker, 1997).

Dr. JoAnn Burkholder, a North Carolina State University scientist, and a colleague in her lab, experienced neurological disorders resulting from exposure to Pfiesteria. The exposure produced short term and long-term memory problems and disorientation. Duke University researchers found that the dinoflagellate, Pfiesteria, caused serious learning impairment in rats (Levin et al., 1997). The learning deficits seen in this study may provide a partial model for the cognitive problems seen in the NCSU laboratory personnel who were accidentally exposed to Pfiesteria. However, the study does not necessarily translate to an understanding of risks involving human exposure in the field.

In August of 1997, the state of Maryland responded quickly to a major fish kill on the lower Pocomoke River, which left thousands of fish dead or covered with bleeding sores (Environmental News Service, 1997). A special medical team was brought in to respond to the reported health effects. People were reporting burning skin sensations following contact with the water, respiratory irritation, and the onset of concentration difficulties. The Maryland Department of Health and Mental Hygiene announced that a toxin, similar to Pfiesteria, might be the cause of the symptoms. Maryland Governor Parris Glendening felt there was enough information to act and felt the public should be informed of the connection to human health concerns. The response of Maryland officials brought this issue to attention of the nation. As a result, increased federal money for research is now available.

Further work investigating the connection between exposure to Pfiesteria and human health effects was reported by Maryland researchers (Grattan et al., 1998). The first complaints indicating there might be a problem for commercial fishermen began in the spring of 1997 when some reported to the county health department experiencing fatigue, headache, respiratory irritation, diarrhea, weight loss, skin irritation and rashes, and memory difficulties. The Maryland Department of Health and Hygiene called for further assessment of those exposed.

Twenty-four people who had been exposed to the Pfiesteria toxin were followed over a several month period. Exposure history and symptoms were recorded; in addition, a complete medical and laboratory assessment was conducted. A neuropsychological screening battery was performed and test results were compared to the performance of a control group. Results indicated that people with high exposure were significantly more likely to complain of symptoms such as: new or increased forgetfulness, headache and skin lesions or a burning sensation of the skin upon contact with water. Additional tests showed the exposed group was having difficulty with learning and higher cognitive functions. The higher the exposure the greater the difficulty. Eight- seven percent of the high exposure group experienced learning and memory problems (Roper, 1998). Approximately 3-6 months after the cessation of the exposure, test scores returned to within a normal range. However, those most severely exposed continued to have some deficient performance, although overall improvement was noted. When studied again at 6 months post-exposure, they reported improvement in memory function and had normal performances on all cognitive measures.

Further research conducted by Dr. Kenneth Hudnell, an EPA neurotoxicologist, found that contact with Pfiesteria contaminated waters might adversely affect a person's ability to distinguish visual patterns. In a preliminary study, Dr. Hudnell found that one's ability to detect visual patterns was reduced by about 30 percent (Brown, 1998). Such a deficit in contrast sensitivity may cause people to perform tasks more slowly and may have the effect of increasing the risk of accidents. This was the first study to show that exposure to Pfiesteria contaminated waters may affect vision. Since none of the subjects had been exposed recently, this study is the first suggestion that persistent health effects are possible. In a North Carolina study of people potentially exposed to Pfiesteria water,

medical evaluations did not find severe, chronic or widespread effects (Roper, 1998). Further studies are underway to address the limitations of the NC study.

The NC Department of the Environment and Natural Resources has recently responded to the environmental and human health concerns about Pfiesteria by:

- creating in the Spring of 1998, a Harmful Algal Blooms program to monitor the potential health effects of Pfiesteria;
- setting-up a toll-free hotline for citizens to report potential problems and to receive information;
- posting warning signs on the Lower Neuse to advise people to avoid dead, dying and sick fish;
- setting a 30% nitrogen reduction plan for the Neuse;
- creating rapid response teams for the Neuse and Tar-Pamlico rivers to investigate fish kills and gather water quality information;
- using $365,000 in federal funds for further monitoring efforts;
- seeking $221 million to assist farmers in the control of nutrient run-off; and
- working with CDC and researchers from Maryland and Virginia to track 100 individuals exposed to Pfiesteria (Brown, 1998).

3.3 Vibrio Vulnificus

Another related issue to the hog industry and the increase of nutrients in surface waters is the appearance of the marine vibrios, Vibrio Vulnificus. Researchers are studying the correlation between the deadly organism and high nutrient waters polluted in part by livestock. The CDC considers vibrios an emerging disease and NC health officials plan to track reports of the illness.

Section Four: Infectious Disease

Within the intestinal tract of swine, many bacteria, viruses, and protozoa live, some of which can be pathogenic to humans (Swinker, 1998). Those at most risk from exposure are pork production employees, especially those that have contact with the animals, carcasses, parts or by-products associated with the killing floor of the swine processing/slaughter plants (Fowler, et al., 1998). As the waste from hogs is spread over the soil and infiltrates some water supplies, there is concern about the exposure of humans to possible infectious diseases.

Coliform bacteria, when found in drinking water, indicates microbiologic activity and contamination by fecal material. The presence of E. coli is usually caused by fecal matter from warm-blooded animals. In Indiana, there was an outbreak of sickness due to exposure to E. coli bacteria (Wire Report, 1998). Twenty-one people became ill in a two-day period. E-coli causes diarrhea, nausea, fever, and dehydration. All of the Indiana cases were adults. Added to this concern of exposure to coliform bacteria is the

increase in potency of some of the viruses and bacteria found in animals, including hogs. Some of these bacteria are increasingly resistant to common antibiotics.

Enteroviruses are carried by swine and predominantly spread from hogs to humans through direct contact with the animals. Enteroviruses aerosolized by agitation tanks in municipal wastewater treatment plants can pose a health risk to workers at the plants (Swinker, 1998). As North Carolina looks to phase out anerobic lagoons and possibly replace them with aerobic lagoons, exposure to enteroviruses will need to be watched. Aerobic lagoons entail the agitation of the wastewater to introduce oxygen to assist in the breakdown of organic matter. Workers will need protection from possible exposure to aerosolized Enteroviruses resulting from this process.

The intestinal tract of hogs is an important reservoir of salmonella: A study of over 2200 North Carolina swine found that 25% harbored salmonella species in their feces (Davies, et al., 1997). Several of the species found are capable of infecting humans. From 1989 to 1995 the hog population increased in North Carolina from 2.7 to 7 million. During this time, the annual incidence of reported salmonella infections was constant at a mean of 1173 cases annually. The 11 leading hog-producing counties contribute 10-12% of the reported salmonella cases, with the majority of the state's reported cases coming from the urban, more densely populated areas. At present, modern production methods, although still fairly new in the state, do not seem to increase nor reduce the prevalence of enteric organisms in the hog population (Fowler et al., 1998). The salmonella rate should continue to be studied as the hog waste is continuously applied to soils.

Although the rate of salmonella infections has remained steady, the risk of human infection remains a concern. Future efforts to ensure the safety of pork should include attention to the control of salmonella. Due to the salmonella reservoir of infection present in hogs and the fact that modern intensive livestock production practices result in large pools of contaminated water and soil, this has raised concerns about the safety of the water supplies of nearby neighbors. The soil and water in the drainage areas should be checked for infectious agents around hog intensive livestock operations. Additionally the state should follow closely hog-associated infections. This can be facilitated by adding such infections to the list of reportable conditions (Fowler et al., 1998).

4.1 Worker Exposure to Infectious Agents

Similar to the concerns about air pollutants, workers are more at risk than the general population concerning exposure to infectious agents present in hogs. In addition to the exposure to hazardous dusts and gases, certain infectious agents that affect the respiratory tract can pass from the animals to humans. These include: swine influenza, ornithosis, and Q fever. Workers employed in the hog industry are also exposed to infectious agents through exposure to animals in the slaughterhouse and in particular on the killing floor. In 1961, a unified national program was mounted to eradicate brucellosis from the nation's hog population. Although highly successful, the bacteria is

still found in some herds throughout the country. In December of 1993, thirty-four swineherds nationwide were under quarantine for brucellosis in seven states. Packing plants that handle infected swine, however, do not follow special procedures to prevent occupational exposure.

North Carolina workers who were employed in hog slaughterhouses were exposed to brucellosis (Trout et al., 1995). In a study of workers at a particular facility, 19% of the kill floor workers were found to have evidence of recent or persistent brucellosis. Of the 154 study participants, one hundred and five (68%) reported experiencing two or more symptoms consistent with brucellosis during the previous year. The most common symptoms included chills, fever, headache, and myalgia/arthralgia.

Transmission of the bacteria, brucellosis, to humans can occur during the slaughter of infected swine through worker skin lesions, inhalation of aerosols, conjunctival contact and ingestion. Person-to-person transmission is rare. The study results pointed to skin exposure, and possibly conjunctival contact, as the most likely path of exposure. Infectious tissue or body fluids appeared to be the primary exposure route in the plant. Brucellosis is considered an under-diagnosed disease. Periodic and ongoing screening is warranted, in addition to the exclusion of infected herds from entering the slaughterhouses in the first place. Although the disease is treatable with antibiotics, fatigue can persist for months afterwards and can result in disability. Relapse illness can occur.

4.2 Increased Virulence in Salmonella

Virulent forms of salmonella are on the increase in the United States. In 1996 34% of the salmonella cultures sampled in labs were found to be of the type DT104 (Salmonella enterica serotype typhimurium), which is resistant to most major antibiotics, including ampicillin, streptomycin, and tetracycline (Glynn et al., 1998). In 1979-80 only .6% of the bacteria salmonella that was tested was found to be DT104. The routine prophylactic use of antibiotics in livestock feed has helped fuel the evolution of this drug-resistant bacterial strain. This type of Salmonella is recognized as a major cause of illness in humans and animals in Europe. Glynn et al analyzed data collected by local and state health departments and public health laboratories. They concluded that multi-drug-resistant typhimurium has become a widespread pathogen in the United States and recommended a more prudent use of antimicrobial agents in farm animals and more effective disease prevention on farms. They estimate that in the United States, that each year there are an estimated 800,000 to 4 million salmonella infections, of which 500 are fatal, and approximately 40,000 are confirmed by culture (Glynn et al., 1998).

In addition to the above mentioned Salmonella, E-coli strains that are antibiotic resistant are becoming more common. A new potent version of staph has emerged. Staphylococcus aureus bacteria has recently not responded to the most potent antibiotic, vancomycin, and appears to have taken the life of a patient in New York (Dobnik, 1998). Doctors have been warning of the emergence of several drug-resistant

bacteria, which can be attributed to the misuse and overuse of antibiotics both by humans and in animal production operations.

Some of these antibiotic resistant organisms arise from animal farming practices, including swine production, which involves the prophylactic use of antibiotics in the feed. With time, bacteria develop resistance to antibiotics by various means including by creating chemicals that weaken a drug's potency. Resistance can develop quickly. Vulnerable populations, such as the elderly, infants, and people with suppressed immune systems, are at a greater risk to drug-resistant species, as are farm workers themselves (Galvin, 1998). Human exposure to antibiotic-resistant bacteria from animals is most likely caused by improper food processing, storing, or cooking.

Of great concern is the increase in infections with antibiotic-resistant staphylococci and enterococci that cannot be treated (Witte, 1998). Such infections have a prime opportunity to develop and transfer in the hospital environment given the concentrated combination of bacteria adapted to this environment, patients prone to infections, and antibiotic use. Each year it is estimated that as many as two million Americans acquire a nosocomial infection, meaning one that they did not have when they were admitted to the hospital. As estimated by Dr. Stuart B. Levy, with the Tufts University School of Medicine, over 20,000 people die from these hospital-borne infections each year (President and Fellows of Harvard College, 1997).

4.3 The Prophylactic Use of Antibiotics

The nation's hogs, poultry, and cattle are fed 19 million pounds of antibiotics a year to enhance growth and protect against disease (Mansur, 1998). In a recently released study by the National Research Council, it was acknowledged for the first time that this practice presents a threat to public health. The study noted that this practice has in some instances led to the passage of resistant bacteria from animals to humans. The prophylactic use of antibiotics at subtherapeutic amounts allows more animals to be raised at lower costs (Galvin, 1998). There are two to three times more livestock than people in the U.S. and therefore many consider the use of antibiotics in animals to be a more important contributor to the environmental pool of resistant strains than that from humans (Harvard College President and Fellows, 1997).

The dependence on the use of antibiotics is caused by the emergence of intensive livestock operations, where by definition large numbers of animals are produced in close proximity. Hogs grown in ILOs are often in constant contact with other hogs, which results in a need for antibiotics to fight against the transmission of infections. Because these animals are regularly exposed to small amounts of antibiotics, any microbes they are carrying are more likely with time to develop a resistance. Antibiotics are also used in animal husbandry for prophylaxis, chemotherapy, and growth promotion. Antibiotic resistance affects such zoonotic pathogens as Salmonella serovars and Campylobacter spp., both of which are associated with diarrheal diseases, and Escherichia coli and Enterococci. The microbial ecosystems in humans and animals are intertwined and microbial antibiotic resistance readily crosses boundaries (Witte, 1998). Since meat

products are traded worldwide and bacterial populations do not limit themselves to geographic boundaries, the problems caused by the inappropriate use of antibiotics are global in nature.

An examination of current animal-management practices, and improvement of such, could result in a reduction in the need for antibiotics. In addition, the development of effective vaccines will help reduce the demand for antibiotics (Galvin, 1998).

Drug resistant bacteria can pass from animals to humans by multiple means. They include: direct contact with the animals or their waste; exposure to food contaminated by the bacteria; or by person-to-person contact (Mansur, 1998). Commenting on the National Research Council study, Jean Halloran, the director of the Consumer Policy Institute for the Consumer's Union of United States Inc., who served on the study committee stated: There's been some debate, especially in agribusiness, that says the use of antibiotics in animals is a separate pool (from the human pool) and the animal usage can't affect the resistance problem that people have....The committee concluded this was not a debate. It said, "This is not true. The pools overlap."

The Center for Science in the Public Interest has advocated for a policy response to this issue. They have asked for a government ban on the routine use of antibiotics in food animals. The findings of the National Research Council committee called for better oversight of the issue through the creation of a national database on the use of antibiotics and resistance trends; the establishment of a national oversight panel; and more research money for the development of new antibiotics (Mansur, 1998). Vigilance is needed to prevent the spread of bacteria that are resistant to present drugs.

Of further concern is the tainting of the nation's meat supply and its impact on human health. Some polls show that consumers are more worried about bad meat than violent crime. Figures estimate that there are as many as 81 million cases of food-borne illnesses a year, which result in approximately 9,100 deaths. It is believed that the cost of foodborne disease is as high as 5 billion dollars (Altekruse et al., 1997). The exact numbers of illnesses are being challenged by the CDC, which expects to release their own numbers. The Clinton administration, however, is trying to toughen national food laws in response to these concerns regardless of the exact numbers determined (*LA Times*, 1998).

4.4 Other Swine Intestinal Tract Pathogens

The intestinal tract of swine can carry numerous bacteria, viruses, and protozoa, which can be pathogenic to humans in addition to E-coli, Salmonella and Brucellosis. They include: Trichinosis, Toxoplasmosis, Leptospirosis, Erysipelothrix, Cryptosporidium, Streptococcus suis, and Yersinia enterocolitica (Fowler, 1998; Swinker, 1998). Although these pathogens may be fairly uncommon, there may be incidents that go undetected and unreported given lack of physician training in infectious diseases and insufficient resources to properly diagnose such.

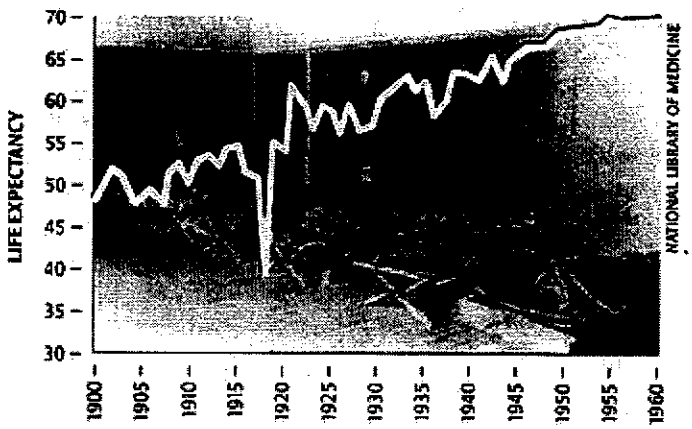
Dr. Hervey Kornegay, a Duplin County physician, has taken a leadership role in working for improved safeguards to protect public health concerning the impact of hog ILOs in his county. Dr. Kornegay's interest in the health impacts of the industry are based on his professional background as a practicing physician in the community, his community service work as Chair of the Duplin County Board of Health, and as a father. During the summer of 1996, Dr. Kornegay's son attended a camp in Johnston County. The camp's lake was situated downhill from two ILOs, including a swine ILO. While at camp, his son contracted leptospirosis, a rare and unusual disease. Dr. Kornegay's son was hospitalized for five days with high fever. Dr. Kornegay recommends that physicians in eastern North Carolina consider this pathogen as a potential causal agent when children and adults report unusual febrile illnesses. The origin of the infection was never determined, however, one possible source was from the large adjacent hog operation. Even with assistance from the Centers for Disease Control a final determination was not made.

4.5 Swine or Spanish Flu of 1918

Here in North Carolina, close attention is paid to the possible transmission of disease from humans to swine. When people enter a hog house, they must wear special gear to protect the animals from exposure to viruses or bacteria carried by humans. Two family members can not seek employment in differing hog ILOs given concern over cross contamination between the herds. Equal protection and attention does not appear to be given concerning human exposure from viruses and bacteria that are found in hogs. This omission could have catastrophic repercussions.

In 1918, the flu pandemic, which was also known as the Swine flu, Pig flu, and Spanish flu, swept the world and in little over one year's time between 20-40 million people died. In the United States alone, approximately 675,000 people died. It is estimated that 28% of the U.S. population was infected with the virus. (Taubenberger et al., 1997)

Ten times more people died from the swine flu than during World War I and almost twice as many as have died from the AIDS epidemic. Additionally, most of the deaths from the Swine Flu took place within a one-year period, whereas the AIDS' deaths have been spread over a fifteen-year period. The Swine Flu of 1918 was particularly virulent with mortality rates among the infected of over 2.5%, while other flus have less than a 0.1% death rate. The death rate was so high that it depressed the life expectancy in the U.S. by more than 10 years.



The Swine Flu of 1918 was different from any other flu before or since. Usually the youngest and oldest sectors of the population or those with a repressed immune system are most vulnerable. However, in 1918 young adult males,

seemingly exceptionally healthy ones, were most likely to be struck by the disease. Once afflicted, most died within 24-48 hours. Young males were at the time of the flu outbreak mobilizing for World War I and were concentrated in military camps and on boats. This facilitated the spread of the flu among the troops and enabled the virus to move quickly through populations worldwide.

Researchers today are examining the virulent form of the Swine Flu virus. Knowledge of what this virus looks like could help health officials to identify dangerous flu strains as they emerge. Nancy Cox, a virologist with the Centers for Disease Control and Prevention (CDC), stated that study of this particular strain of the virus is needed to, "help us prepare for what we need to be prepared for." (Pennisi, 1997) The flu virus of 1918 infected the respiratory system, replicated, and then dispersed into the air via the lungs. Often all traces of the virus had disappeared by the time an autopsy was performed. Given the number of deaths from the Swine Flu, coupled with the war deaths, just disposing of the bodies became a problem, let alone having the resources to perform autopsies.

4.6 Hog as 'Mixing Vessel' for Avian and Human Viruses

Influenza A virus can escape the human immune response through antigenic drift (mutation), antigenic shift, or by the introduction of an avian virus into pigs. When introduced into the pig, the virus adapts to the new host, and is then passes on to humans (Scholtissek, 1994). Rarely does an avian influenza virus pass directly to humans. More commonly, the virus first passes through the pig. Data suggest that at the time of the Swine/Spanish Flu that a human influenza A (H1N1) virus entered the pig population and clustered with an "avian like" virus.

Pandemic strains are most likely formed when there is a reassortment of the genes. To assure the earliest possible identification of a pandemic strain, worldwide collaborating laboratories and surveillance system are required (Scholtissek, 1994). Close, continuous, and intensive monitoring of the world's swine population for the earliest possible detection of avian-like influenza viruses needs to be a basic part of global health planning.

Recent successful attempts to study the flu virus by means of polymerase chain reaction methods have allowed researchers to amplify small amounts of DNA and RNA in adequate amounts for sequence analysis. As a result, researchers now believe that the flu-virus genes closely resemble viruses isolated from pigs and that this virus had been in the pig population for a long period. The virologist, Dr. Robert Webster of St. Jude Children's Research Hospital said, "What this says is we had better watch what's happening in the pig populations of the world." (Pennisi, 1997) The pig trachea provides cell surface receptors for both human and avian influenza viruses (Ito et al., 1998). The pig trachea is conducive to viral replication and genetic reassortment. As the viruses replicate, the avian-like swine viruses develop the ability to recognize human virus receptors, and increase the possibility of their direct transmission to human populations (Ito et al., 1998). This allows the pig to act as an intermediate host for the generation of

pandemic influenza viruses as seen in 1918, 1957, 1968, and 1977. Apparently, the pig acts as a 'mixing vessel' for such viruses.

Like the AIDS virus, the flu virus is ever changing. The CDC and the World Health Organization primarily spend their flu-surveillance efforts in examining flu strains in human populations, and not in the potential source itself, the hog. There is an obvious risk of studying such a virulent virus, which can be justified by the need to understand its structure and mechanism. Dr. Webster, when commenting on the 1918 Swine Flu, stated, "We want to know what killed these people. The potential is there for this kind of virus to return." (Pennisi, 1997).

Section Five: Wholistic View of Health Impacts

Our understanding of health and the determinants of health are limited and socially grounded. The language we use to describe the impacts of the intensive livestock operations and NC's newly structured vertically integrated agribusiness rarely includes the issues raised by community members (Wing, 1998). For instance, the vocabulary used to describe the industry is determined by the industry itself, such as, the use of the word 'lagoon' vs. 'cesspool'; 'hog waste' vs. 'hog feces and urine'; 'hog farm' vs. 'hog operation'; 'growing house' vs. 'confinement facility'; 'harvest' vs. 'slaughter'; 'family farm' vs. 'factory farm'; 'agriculture' vs. 'agribusiness' and 'hog farmer' vs. 'hog operator/producer'. The top, powerful, rich controllers of the industry are called 'integrators'. The industry preferred vocabulary frames the way in which the industry is conceptualized in a more friendly, positive manner. One would not mind living near a 'lagoon' but would object to residing next to a 'feces and urine cesspool'. Don Webb, a NC community activist and founder and leader of the Alliance for a Responsible Swine Industry (ARSI), has worked arduously to recapture the vocabulary used to describe the industry, its activities and impacts.

Other issues surrounding the hog industry which are rarely raised include race and class, and the potential disproportionate effect of the industry on poor people of color. Such factors are raised by the environmental justice movement and their consideration of such are included in the Principles of Environmental Justice (EJ). In part fueled by the impacts of NC's hog industry, the state's first ever Summit for Environmental Justice was convened in Edgecombe County, in eastern NC, in October of 1998. National and state leaders of the EJ movement presented their ideas, in addition, to representatives of grassroots community and environmental organizations, state environmental organizations, state environmental agencies, and federal agencies, including EPA and NIEHS. Additional issues not often discussed are the agricultural determinants of nutrition, the loss of natural resources, and the emergence of conditions conducive to new diseases (Wing, 1998).

Policy development looks to risk factor epidemiology for guidance, which uses the paradigm of dividing the population into exposed and unexposed individuals. Such research does not ask the broader questions like:

- where do the exposures come from;
- why are some groups exposed and others not;
- who benefits from producing the exposures;
- are the full range of exposures openly identified and studied;
- are the exposed populations fully informed;
- do they have access to medical care to remedy their exposure; and
- are the exposed populations fully compensated and made whole for their exposure (Wing, 1998)?

These are some of the broader questions the environmental justice movement is trying to raise. Professionals and community activists who challenge the dominant scientific account of health and disease argue that current epidemiological approaches are more likely attuned to protect the economic health of industry versus the health of the population or the environment. Such issues were discussed at the EJ Summit meeting.

By dividing scientific studies of the impact of hog intensive livestock operations into small units where specific diseases and exposures are examined one at a time, the overall effects of the industrial operations are never fully seen nor understood. This is also true of how we study the environment and set standards for emissions and is of importance when considering the effect of the hog industry. Air emissions from hog intensive operations consist of hundreds of constituent gases, none of which routinely exceed federal standards. However, the synergistic effect of all these gases has not been examined. A similar effect is seen when people take multiple medicines, where each one is taken at the prescribed amount, and yet together they can have serious effects when they interact with each other.

Victims of environmental exposures are too often blamed, questioned, isolated, and harassed (Wing, 1998; Tesh, 1988; Reich, 1991). The needs of subpopulations that are particularly vulnerable, such as pregnant women, asthmatic children, or adults with chronic respiratory disease, are rarely considered in policy deliberations. Other groups often overlooked are poor people of color.

Section Six: Recommendations

To assure the health and safety of North Carolina citizens who live near hog intensive livestock operations, further study needs to be made of the health impacts. It is particularly appropriate that such studies take place here since NC is the birthplace of this new concentrated livestock configuration. Additionally, the state's hog ILOs are more concentrated in one particular area of the state with sandy soils and a high water table. The impacts may prove to be greater here, especially due to the concentration of

operations in two counties, than anywhere else in the nation. Based on the review of the research literature of hogs and human health, the following recommendations are made:

- conduct a health study of the families who were found to be consuming nitrate contaminated well water (state and university researchers)
- test well water for coliform, in addition to nitrates (county staff);
- study the mental and physical health effects on residents of Duplin and Sampson counties, especially those living in odor affected areas (state and university researchers):
- conduct a clinical study of the impact of exposure to hog waste odors on asthmatics (state and university researchers);
- establish a state standard for odor (NC Environmental Management Commission);
- check North Carolina's hog herd periodically for such infectious agents as Salmonella DT 104, and any avian viruses (NC Department of Agriculture);
- establish a protocol for communication and collaboration (NC Dept. of Ag., NC Occupational Safety and Health, county health department, and the State Health Director's Office) to assure a comprehensive response to the detection of swine diseases that could transfer to humans. This should include a protocol for handling potential emergencies and informing of the public; and
- develop a central database of demographic, psychological, and medical variables for persons exposed to hog odors and contaminated water and soil. Such a data base should include such markers as immunologic, neurologic, endocrinologic, psychologic and social factors (NC State Health Director's Office).

Conclusions

There is a well-established literature describing the health effects of workers employed in both the confinement houses and the slaughter facilities of the hog industry. Two preliminary studies of the impact of the hog industry on neighbors were recently conducted. They concluded that in the physical health area, adjacent neighbors experience similar symptoms to employees only less severe and less frequent. In the mental health area, residents living in the odor-affected area were found to have increased incidents of mental health problems. These preliminary studies need to be redone in a more comprehensive and rigorous manner to ascertain the validity of their findings. The current status of the understanding of the potential threat to human health from hog operations is better described as what appears to be a problem or a potential problem, versus what is clearly understood. More research is needed to better understand the impacts of air and water emissions from hog intensive livestock operations and possible exposure to hog infectious agents. This is especially important given the potential for pandemic disease as the hog acts as a 'mixing vessel' between human and avian influenza viruses. Of additional concern is the increased presence of antibiotic resistant strains of bacteria, such as Salmonella (DT104), of which the pig is

one of several potential sources. Increased funding for research efforts is needed to address such issues.

References

1. Dead hogs are dumped in Edgecombe creek. (1998 December). *The News & Observer.*

2. Aitken, M., & Okun, M. F. (1991). *Investigation of odor problems associated with wastewater treatment facilities in North Carolina.* (Report No. Special Report Series No. 6, Project No. 50157). Water Resources Research Institute of North Carolina.

3. Aitken, M., & Okun, M. F. (1992). Quantification of wastewater odors by the affected public. *Water Environment Research, Vol. 64*(No. 5), 720-727.
4. Alfred W. Crosby. (1989). *America's Forgotten Pandemic: The Influenza of 1918.* Cambridge: Cambridge University Press.

5. Altekruse, S. F., Cohen, M. L., & Swerdlow, D. L. (1997). Emerging foodborne diseases. *Emerging Infectious Diseases, 3*(3), CDC Website.

6. Aneja, V. P., Murray, G. C., & Southerland, J. (1998). Atmospheric Nitrogen compouonds: emissions, transport, transformation, deposition, and assessment. *r & Waste Management Association's Magazine for Environmental Managers,* pp 22-25.

7. Arbuckle, T. E., Sherman, G. J., & Corey, P. N. (1988). Water nitrates and CNS birth defects: a population-based case-control study. *Archives of Environmental Health, Vol. 43*(No. 2), pp. 162-167.

8. Associated Press. (1998 November). EPA joins challenge to NC hog regulation. *The News & Observer,* p. 8.
9. Barker, R. (1997). And the Waters Turned to Blood. New York: Simon & Schuster.

10. Beauchamp, D. E. (1988). *The Health of the Republic: Epidemics, Medicine, and Moralism as Challenges to Democracy.* Philadelphia: Temple University Press.

11. Beveridge, W. I. B. (1977). *Influenza: the last great plague- an unfinished story of discovery.* New York: Prodist.
12. Brown, A. (1998). *North Carolina task force on fish kill waters and EPA present findings of pfiesteria study.* Raleigh NC.

13. Centers for Disease Control and Prevention. (1994). *Addressing emerging infectious disease threats- a prevention strategy for the United States.* Atlanta GA: U.S. Department of Health & Human Services, Public Health Service.

14. Clabby, C. (1997 March). Illness may be linked to Neuse- Craven County doctors concerned about river's pollution. *The News & Observer.*

15. Clabby, C. (1998 September). Pfiesteria affects vision, scientist finds. *News & Observer.*

16. Colborn, T. (1995). Environmental estrogens: health implications for humans and wildlife. *Environmental Health Perspectives, 103*(Suppl 7), 135-136.

17. Conlisk, E., Siegel, M., Lengerich, E., Mac Kenzie, W., Malek, S., & Eriksen, M. (1995). The status of local smoking regulations in North Carolina following a state preemption bill. *Journal of the American Medical Association, Vol. 273*(No. 10), pp. 805-807.

18. Cooper, M. (1997). The heartland's raw deal: how meatpacking is creating a new immigrant underclass. *The Nation, Vol. 264*(No. 4), pp. 11-17.

19. Copeland, J. D. (1991). *Legal liability for worker health problems.* Des Moines, Iowa: National Pork Producers Council.

20. Davies, P. R., Morrow, W. E. M., Jones, F. T., Deen, J., Fedorka-Cray, P. J., & Harris, I. T. (1997). Prevalence of salmonella in finishing swine raised in different production systems in North Carolina, USA. *Epidemiology & Infectious Disease, 119*, pp. 237-244.

21. Dobnik, V. (1998 April). Supergerm suspected in man's death. *News & Observer.*

22. Donham, K. J. (1986). Hazardous agents in agricultural dusts and methods of evaluation. *American Journal of Industrial Medicine, 10*, pp 205-220.

23. Donham, K. J. (1991). Health concerns from the air enviornment in intensive swine housing: where have we come from and where are we going? *Making Swine Buildings a Safer Place to Work* Des Moines, Iowa: National Pork Producers Council.

24. Donham, K. J. (1990). Health effects from work in swine confinement buildings. *American Journal of Industrial Medicine, 17*, 17-25.

25. Donham, K. J. (1993). Respiratory disease hazards to workers in livestock and poultry confinement structures. *Seminars in Respiratory Medicine, Vol. 14, No. 1*, 49-59.

26. Donham, K. J., & Leininger, J. R. (1984). Animal studies of potential chronic lung disease of workers in swine confinement buildings. *American Journal of Veterinary Research, Vol. 45, No. 5*, 926-931.

27. Donham, K. J., & Popendorf, W. J. (1985). Ambient levels of selected gases inside swine confinement buildings. *American Industrial Hygiene Association Journal, 46(11)*, 658-661.

28. Editor. (1998 April). Chatham's handle on hogs. *The News & Observer.*

29. Editor. (1998 March). Counties must fill the gaps. *Winston-Salem Journal*, p. A10.

30. Editor. (1998 June). Some brighter rays on the hog horizon. *Greensboro News & Record.*

31. Editor. (1998 July). Staunching the stench. *News & Observer.*

32. Edwards, R. (1998). *The benefits of swine regulations outweigh the disadvantages: results from the 1997 annual survey of eastern North Carolina.*

33. Environment News Service. (1997). Pocomoke River Sickness Affects Humans (Version Web Posting) [EnviroLink Network].

34. Feagans, B. (1998 April). Couple say hog lagoon loophole ruins home. *Wilmington Star.*

35. Feagans, B. (1998 April). Hog waste has polluted drinking water, state says. *Wilmington Star.*

36. Flowers, L. (1990). *Throwed away: failures of progress in eastern North Carolina*. Knoxville TN: University of Tennessee Press.

37. Fowler Jr., V. G., Xanthakos, S., & Corey, G. R. (1998). Of Hogs and Men: Does North Carolina's Hog Industry Raise the Risks of Infectious Disease? *North Carolina Medical Journal, 59*(No. 1), 12-15.

38. Freudenburg, W. R., & Gramling, R. (1994). *Oil in Troubled Waters*. Albany: State University of New York Press.

39. Gallagher, J. J. (1981). Models for policy analysis: child and family policy. R. Haskins, & J. J. Gallagher *Models for Analysis of Social Policy* . Norwood, NJ: ABLEX Publishing Corporation.

40. Galvin, M. (1998 July). Antibiotic Use in Food Animals Contributes to Microbe Resistance. *Press Release: National Research Council*, pp. 1-4.

41. Glynn, M. K., Bopp, C., Dewitt, W., Dabney, P., Mokhtar, M., & Angulo, F. J. (1998). Emergence of multidrug-resistant Salmonella Enterica Serotype Typhimurium DT104 infections in the United States. *New England Journal of Medicine, 338(19)*, pp 1333-1338.

42. Grattan, L., Oldach, D., Perl, T. M., Lowitt, M. H., Matuszak, D. L., Dickson, C., Parrott, C., Shoemaker, R. C., Kauffman, C. L., Wasserman, M. P., Hebel, J. R., Charache, P., & Morris Jr., J. G. (1998). Learning and memory difficulties after environmental exposure to waterways containing toxin-producing Pfiesteria or Pfiesteria-like dinoflagellates. *The Lancet, Vol. 352*, pp.530-539.

43. Harvard College President and Fellows, Cabot, J. E., & Goldberg, R. A. (1997). *Technology crisis and the future of agribusiness: antibiotic resistance in humans and animals.* (Report No. 598-024). Cambridge, MA: Harvard Business School.

44. Heath Jr., M. S. (1996). Intensive livestock operations in North Carolina: cases and materials. *Environmental and Conservtion Law,* (No. 2).

45. Herget, B. (1991). Pork Palace: Murphy Farms Raises Pigs with 20th Century Technology. *North Carolina,* 28-29.

46. Hoehling, A. A. (1961). *The great epidemic.* Boston MA: Little, Brown and Company.

47. Holtkamp, J., O'Gorman, D., & Otto, D. (1994). *Community perceptions of water quality impacts from large-scale hog confinements.* (Report No. Staff Paper No. 261). Iowa State University:

48. Ibsen, H. J. (1995). *Enemy of the people.* Lyme, New Hampshire: A Smith and Kraus Book.

49. Institute of Medicine. (1988). *The Future of Public Health.* Washington, D.C.: National Academy Press.

50. Ito, T., Nelson, J., Couceiro, S. S., Kelm, S., Baum, L. G., Krauss, S., Castrucci, M. R., Donatelli, I., Kida, H., Paulson, J. C., Webster, R. G., & Kawaoka, Y. (1998). Molecular basis for the generation in pigs of influenza A viruses with pandemic potential. *Journal of Virology, 72*, pp. 7367-7373.

51. Jennings, G. D., Sneed, R. E., Huffman, R. H., Humenik, F. J., & Smolen, M. D. (1991). Nitrate and pesticide occurrence in North Carolina wells. *American Society of Agricultural Engineers International Meeting* .

52. Jones, L. (1994). *Appalachian values.* Ashland KY: Jesse Stuart Foundation.

53. Judge Wynn (NC Court of Appeals). (1998). Parker v. Barefoot (No. COA97-713).

54. Koren, H. S. (1995). Associations between criteria air pollutants and Asthma. *Environmental Health Perspectives, 103*(Supplement 6), pp. 235-242.

55. Kornegay, H. (1998). Hogs and Health. *North Carolina Medical Journal, Vol 59*(#2), Letters to the Editor.

56. Kristensen, P., Andersen, A., Irgens, L. M., Bye, A. S., & Sundheim, L. (1996). Cancer in offspring of parents engaged in agricultural activities in Norway: incidence and risk factors in the farm environment. *International Journal of Cancer, 65*, pp. 39-50.

57. LA Times. (1998 October). Food poisoning data in dispute. *The News & Observer*, p. 17A.

58. Lang, J. (1998 April). Nation's lifestock waste poses massive problem. *The News & Observer.*

59. Law Engineering and Environmental Services Inc. (1996). *Review of current regulatory framework and industry practices for swine waste management systems.* Raleigh, NC.

60. Leavenworth, S. (1996 December). Tests find many wells contaminated. *The News & Observer*, pp. 1, 24.

61. Levin, E. D., Schmechel, D. E., Burkholder, J. M., Glasgow, Jr. H. B., Deamer-Melia, N. J., Moser, V. C., & Harry, G. J. (1997). Persisting learning deficits in rats after exposure to Pfiesteria piscicida. *Environmental Health Perspectives, Vol. 105*(No. 12), pp. 1321-1325.

62. Mansur, M. (1998 July). Risk of feeding animals antibiotics is shown. *The News & Observer*, p. 13.

63. McBride, A. D. (1998). *The association of health effects with exposure to odors from hog farm operations.* Raleigh NC: NC Department of Health and Human Services.

64. McCarthy, M. P. (1987). *Typhoid and the politics of public health in nineteenth-century Philadelphia.* Philadelphia: American Philosophical Society.

65. Meyer, T. (1996 July). Hog waste may have aborted pregnancies. *Raleigh News & Observer.*

66. Milio, N. (1989). *Promoting health through public policy.* Ottawa: Canadian Public Health Association.

67. Mitchell, J. (1997). Now, 'Mad Pig' disease. *Newsweek*, 61.

68. MMWR. (1996). *Spontaneous abortions possibly related to ingestion of nitrate-contaminated well water- LaGrange County, Indiana, 1991-1994.* (Report No. Vol. 45/No. 26). Atlanta Georgia: Centers for Disease Control and Prevention.

69. Monath, T. P., Cropp, C. B., & Harrison, A. K. (1983). Mode of entry of a neurotropic arbovirus into the central nervous system. *Laboratory Investigation, Vol. 48*(No. 4), pp. 399-409.

70. Moore, A., Herwaldt, B. L., Craun, G. F., Calderon, R. L., Highsmith, A. K., & Juranek, D. D. (1993). Surveillance for waterborne disease outbreaks- United States, 1991-1992. *MMWR, Vol 42*(No. SS-5), pp. 1-22.

71. Neal, S. (1998 March). Sending out an SOS for the future- problems caused by hog waste inspired leaders to form save our state. *Winston-Salem Journal.*

72. Neff, J. (1997 April). Hog backers hail well water study. *The News & Observer*, p. 4B.

73. Nugent, M., & Kamrin, M. (1988). *Nitrate-- a drinking water concern.* Community Assistance Program/Center for Environmental Toxicology and Department of Resource Development.

74. Patton, M. Q. (1990). *Qualitative Evaluation and Research Methods* (Second ed.). Newbury Park: Sage Publications.

75. Pennisi, E. (1997). First genes isolated from the deadly 1918 flu virus. *Science, Volume 275*, p. 1739.

76. President and Fellows of Harvard College. (1997). Technology crisis and the future of agribusiness: antibiotic resistance in humans and animals. *Harvard Business School, N9-598-024*, pp. 1-43.

77. Raymer, J. H., Pellizzari, E. D., Thomas, K. W., & Cooper, S. D. (1991). Elimination of volatile organic compounds in breath after exposure to occupational and environmental microenvironments. *Journal of Exposure Analysis and Environmental Epidemiology, Vol. 1*(No. 4), pp. 439-451.

78. Reich, M. R. (1991). *Toxic Politics: Responding to Chemical Disasters.* Ithaca: Comell University Press.

79. Reynolds, S. J., Donham, K. J., Stookesberry, J., Thorne, P. S., Subramanian, P., Thu, K., & Whitten, P. (1997). Air quality assessments in the vicinity of swine production facilities. *Journal of Agromedicine, Vol. 4*(No. 1/2), pp. 37-46.

80. Rist, R. C. (1994). Influencing the policy process with qualitative research. N. K. Denzin, & Y. S. Lincoln *Handbook of qualitative research* (pp. 545-557). Thousand Oaks, CA: Sage Publications, Inc.

81. Rogers, D. (1997 January). No pity for pork farmers. *The News & Observer.*

82. Roper, W. (1998). *North Carolina Task Force on health risk of exposure to fish kill waters .* Raleigh NC: NC Department of Health and Human Services.

83. Ross, J. A. (1996). *Childhood cancer and farming: is it the chicken or the pig?* Minneapolis MN: University of Minnesota.

84. Rudo, K. *Memo to Dennis McBride Re: nitrate well water testing program adjacent to intensive livestock operations .* August 14, 1998:

85. Rudo, K. (1996). *Report summarizing results of well testing program adjacent to hog intensive livestock operations.*

86. Rylander, R., Donham, K. J., Hjort, C., Brouwer, R., & Heederik, D. (1989). Effects of exposure to dust in swine confinement buildings- a working group report. *Scandinavian Journal of Work Environmental Health, 15*, 309-312.

87. Rylander, R., Essle, N., & Donham, K. (1990). Brochial hyperreactivity among pig and dairy farmers. *American Journal of Industrial Medicine, 17*, pp. 66-69.

88. Schiffman, S. (1996). *Characterization of odors from swine operations- final report.* Durham, North Carolina: NC Pork Producers Council.

89. Schiffman, S. S. (1998). Livestock Odors: Implications for Human Health and Well-Being. *Journal of Animal Science, 76*, 1343-1355.

90. Schiffman, S. S., Sattely Miller, E. A., Suggs, M. S., & Graham, B. G. (1995). The Effect of Environmental Odors Emanating From Commercial Swine Operations on the Mood of Nearby Residents. *Brain Research Bulletin, Vol. 37, No. 4*, pp. 369-375.

91. Scholtissek, C. (1994). Source for influenza pandemics. *European Journal of Epidemiology, 10(4)*, pp. 455-8.

92. Schultz, U., Fitch, W. M., Ludwig, S., Mandler, J., & Scholtissek, C. (1991). Evolution of pig influenza viruses. *Virology, 183(1)*, Abstract.

93. Shiffer, J. E. (1998 December). Judge orders strict permit for hog farm. *The News & Observer.*

94. Shim M.D., C., & Williams Jr. M.D., M. H. (1986). Effect of Odors in Asthma. *American Journal of Medicine, Vol. 80*, 18-22.

95. Swinker, M. (1998). Human Health Effects of Hog Waste. *North Carolina Medical Journal, 59*(No. 1), 16-18.

96. Taubenberger, J. K., Reid, A. H., Krafft, A. E., Bijwaard, K. E., & Fanning, T. G. (1997). Initial genetic characterization of the 1918 "Spanish" influenza virus. *Science, Vol. 275*, 1793-1796.

97. Tesh, S. N. (1988). *Hidden arguments: political ideology and disease prevention policy.* New Brunswick: Rutgers university press.

98. Thu, K., Donham, K., Ziegenhorn, S., Reynolds, S., Thorne, P. S., Subramanian, P., Whitten, P., & Stookesberry, J. (1997). A control study of the physical and mental health of residents living near a large-scale swine operation. *Journal of Agricultural Safety and Health, 3(1)*, 13-26.

99. Thu, K. M. (1996). Social Issues. *Understanding the impacts of large-scale swine production* (pp. 71-116).

100. Trout, D., Gomez, T., Bernard, B. P., Mueller, C. A., Smith, G. C., Hunter, L., & Kiefer, M. (1995). Outbreak of Brucellosis at a United States pork packing plant. *Journal of Occupational and Environmental Medicine, Vol. 37, No. 37*, 697-703.

101. United States District Court Eastern District of NC. (1997). Judgment in a civil case (case no. 4:97-CV-57-H1).

102. Upshaw, V. (1998 April). Hog waste dangers. *The News & Observer.*

103. Von Essen, S. (unknown). Health effects of work in swine confinement units. Pulmonary and Critical Care Medicine Section, Department of Internal Medicine, University of Nebraska Medical Center, Omaha, Nebraska.

104. Warren, D. W., Walker, J. C., Drake, A. F., & Lutz, R. W. (1994). Effects of odorants and irritants on respiratory behavior. *Laryngoscope, 104*, pp. 623-626.

105. Warrick, J. (1995 October). Tainted wells, poisoned relations. *The News & Observer*, pp. 1, 8.

106. Whittle, D. J. (1996). *The regulation of animal waste in North Carolina.* Raleigh, NC.

107. Williams, T. (1998). Assembly line swine. *Audubon,* 26-33.

108. Wing, S. (1998). Whose epidemiology, whose health? *International Journal of Health Services, Vol. 28, No. 2,* pp. 241-252.

109. Wire Report. (1998 May). E. coli outbreak puzzles authorities. *News & Observer.*

110. Witte, W. (1998). Medical consequences of antibiotic use in agriculture. *Science, 279,* pp 996-997.

111. Yin, R. K. (1994). *Case Study Research: Design and Methods* (Second ed.). Thousand Oaks: Sage Publications.

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