Pathogens in Manure and Contamination of Indiana’s Waters and Rural Population

CFO Rulemaking Discussion Paper

Hoosier Environmental Council
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EXECUTIVE SUMMARY

Estimates show that livestock housed on Concentrated Animal Feeding Operations (CAFOs) generate approximately 300 million tons of manure every year, roughly twice the total manure generated by the U.S. human population. The fact that manure can contain pathogens is well-documented. It is for this reason human waste is treated and pathogens are eliminated. Waste from livestock, however, is not treated and so the pathogens present in livestock waste have the potential to harm human health. While livestock manure is not the only disease vector on farms, the excessive amount of waste and nearly complete lack of treatment for pathogens make manure the most likely vector for pathogenic outbreaks.

Outbreaks of E. coli and other fecal pathogens, livestock-related influenza viruses, and methicillin-resistant staphococcus aureus (MRSA) have illustrated the risks associated with livestock manure. Every year, crops and meat are recalled because of contamination. Most recently, bagged salad was recalled due to Listeria contamination. Vegetables such as tomatoes, green onions, and romaine have all been recalled due to contamination: E. coli, Salmonella, and Listeria have all managed to infect crops. The use of untreated manure as fertilizer on the fields where these crops are grown is the most likely cause of such outbreaks. And if manure is improperly handled or land applied, then these pathogens can impair groundwater, surface waters, and wells.

Indiana has already made an effort to protect rural residents by enacting more stringent E. coli standards; however, these standards are not being met in many waterways. Now that these standards create an impetus to prevent fecal and pathogenic contamination of waterways, the incorporation of best management practices and biosecurity measures in conjunction with strong regulations and a clear penalties schedule will minimize the risk of contamination of water resources.

As the State Chemist of Indiana and the Indiana Department of Environmental Management develop new rules with regards to the storage, use, and distribution of manure the presence of pathogens must be taken into consideration. It is the duty of these entities to protect the waters of the state and the health of the general public by writing rules that will incorporate proper biosecurity and treatment to minimize the risk of pathogenic outbreaks from CAFOs.

By utilizing simple protocols and best management practices, pathogens can be eliminated from manure and contamination of waterways and crops can be avoided. Simple steps such as proper composting and anaerobic digestion can minimize pathogen content. Testing of manure before it is spread on fields can prevent crop contamination. By incorporating these basic procedures and other best management practices into the rules, the State Chemist and the Indiana Department of Environmental Management can prevent future pathogenic outbreaks from improper handling or exposure to livestock manure.
SUMMARY OF ISSUES
Manure is known to contain pathogens – particularly, fecal coliforms. There are numerous pathogens associated with untreated manure; without proper treatment and management, these pathogens can pose a serious health risk to rural residents, water quality, soil quality, and crops. Indiana currently has 822 water bodies (rivers, lakes, and stream segments) impaired for E. coli. The extent of contamination illustrates the danger of improper manure management, and serves as a strong indicator that untreated fecal matter is indeed making its way into the waters of the state.

In this discussion paper we raise three issues regarding pathogen contamination from improper manure management and the duty of IDEM and the State Chemist to protect Indiana’s environmental and public health: (1) pathogens prevalent in livestock manure and how they threaten public health; (2) the avenues by which untreated fecal matter contaminates Indiana’s water resources; and (3) how regulatory bodies can ensure that avenues of pathogen contamination are closed with proper manure management designed to protect public health.

Pathogens in Livestock Manure
The pathogen content in manure is incontrovertible; all manure contains fecal coliforms and fecal streptococcus. However, because of the diet fed to livestock, stressful and often unsanitary living conditions, antibiotics fed to livestock in low daily doses, and the massive concentration and lack of treatment for livestock manure, it can pose serious risks to human health. Livestock manure can contain many pathogens, including:1

- Ascaris;
- Taenia;
- Cryptosporidium;
- Yersinia;
- Salmonella;
- Campylobacter;
- Fecal coliforms;
- Fecal Streptococci; and
- Hepatitis E virus.

All of these pathogens are present in manure, but not all of them pose an equal health risk. Some pathogens, such as Cryptosporidium, are difficult to treat. Some pathogens are potentially deadly, and some are easily communicable to human populations. The three most concerning pathogens associated with livestock and livestock manure, however, are: (1) E. coli 0157:H7; (2) influenza viruses such as H1N1; and (3) methicillin-resistant staphylococcus aureus (MRSA).

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**E. coli 0157:H7**

Found in the intestines and feces of all mammals, E. coli is particularly virulent.2 E. coli and other fecal coliforms are common problems when working with untreated manure, and have been shown to contaminate crops when proper manure management plans are not implemented. E. coli usually contaminates waterways in times of high rain or flooding, but contamination from faulty or leaking manure lagoons or over-application of manure can contaminate waterways and crops during dry weather periods. Testing conducted by the U.S. Fish and Wildlife Service revealed unsafe levels of fecal coliforms and fecal streptococci on fields where manure was applied.3 Studies have shown that dangerous levels of E. coli and other fecal coliforms remain in waterways for at least 61 days after the initial spill, showing that the effects of a single manure spill on the human population can last months.4

An estimated 73,000 cases of food-borne or water-borne E. coli are reported in the U.S. every year. Up to 5,000 cases result in kidney failure, and 3-5% result in death. Of the total number of reported cases, nearly 40% of all E. coli infections result in kidney damage that causes lifelong complications, blindness, or even paralysis.5

This particular strain of E. coli comes from cattle; most humans are exposed when meat is contaminated during slaughter or through contact with manure from infected animals. The 0157:H7 strain is very dangerous to humans. Infection will result in diarrhea and possibly kidney damage; for some people, especially children and people with weakened immune systems, infection can also result in hemolytic uremic syndrome (HUS), which destroys red blood cells and causes kidney damage and eventual death.6

**Influenza Viruses**

Because of the crowded conditions in CAFOs, diseases spread rapidly among the animals. Proper biosecurity programs, including showers and clothing sanitizers, air filters, waste treatment, and pathogen isolation rarely exist on CAFOs;7 rather, air from the barns is pushed out by industrial-scale fans without being filtered, manure is land applied without being treated, and farm workers do not sanitize clothes and shoes on-site before leaving the facilities. Because of improper animal and manure handling and the lack of biosecurity protocol, viruses such as influenza can easily infect farm workers and rural residents near CAFOs.

In the last decade, several forms of pandemic influenza introduced to the human population that also carry strains of animal influenza DNA. Avian influenza, or bird flu, has been reported in the

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4 Studies conducted by Michael Mallin and JoAnn Burkholder, quoted in “Cesspools of Shame: How Factory Farm Lagoons and Sprayfields Threaten Environmental and Public Health”
U.S. since 1997. This form of animal influenza made the leap to humans due to contact with infected poultry; most humans caught the virus through tainted meat, contact with infected birds, and contact with manure from infected birds.  

In the last two years, the swine H1N1 virus, or swine flu, has garnered media attention and incited a pandemic scare. The H1N1 virus is unique in that it contains DNA from multiple forms of influenza; some human, some avian, some swine. This flu virus is transmitted easily from person to person, and usually infects human populations via farm workers or contact with tainted meat or manure. The chances of catching swine flu were calculated before the public scare and revealed that farm workers had a 35.3% chance of infection, veterinarians had a 17.8% chance of infection, and meat processors had a 6.5% chance of infection. Since strains of influenza can travel up to 15-20 km, mere proximity to livestock infected with influenza can become a biosecurity risk.

**Methicillin-Resistant Staphococcus Aureus (MRSA)**

MRSA is one of the biggest threats to arise from CAFOs. Both human medicine and animal agriculture can contribute to the rise of antibiotic-resistant infections, but an estimated 70 percent of antibiotics produced in this country are used on livestock for non-therapeutic purposes, the administration of low daily doses of antibiotics to healthy livestock in order to promote faster growth and prevent disease in unsanitary conditions. That amounts to roughly 20 million pounds of medically important antibiotics, which are also often given to humans.

Anti-biotic resistant pathogens are becoming a medical crisis. The rise of these resistant strains traces to the overuse of antibiotics. Certain strains of antibiotic resistant diseases, including MRSA, have been traced to hospitals and nursing homes. Doctors have begun curtailing the use of antibiotics in an effort to stem the growing resistance crisis.

While human misuse of antibiotics is a contributor, studies indicate that hog farms are the source of a new strain (ST398) of MRSA. MRSA is usually transmitted to the human population through improper manure handling by workers; however, if it is present in manure or animal carcasses that contaminate water resources and/or soil, it can be passed to human populations via food or water resources.

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8 “Key Facts About Avian Influenza (Bird Flu) and Avian Influenza A (H5N1) Virus,” Department of Health and Human Services, Centers for Disease Control and Prevention, June 2006.
Other pathogens pose a risk to human health as well. The 2010 egg recall, in which over 560 million eggs were determined to be contaminated with Salmonella, has illustrated the inadequate biosecurity protocols that exist on some livestock operations. The unsanitary conditions in this particular CAFO, including piles of manure large enough to push exterior doors open, copious numbers of flies and rats in the laying facility, and unchecked wildlife and livestock interaction, resulted in Salmonella contamination of the laying hens, eggs, and facility equipment. Such poor biosecurity measures should not be allowed in the facilities that produce food; regular inspection and enforcement are necessary to prevent future food-borne pathogen outbreaks such as this from occurring in the future.

Avenues of Pathogen Contamination
The primary cause of pathogen contamination is the excessive amount of waste produced by Concentrated Animal Feeding Operations (CAFOs). CAFOs in the U.S. generate more than 300 million tons of manure every year, more than twice the total amount of manure produced by the human population of the United States. In order to properly manage manure and nutrients, the waste should be spread across an area of cropland roughly 1,000 times greater than the feedlot from which the manure is generated. Instead, this massive quantity of manure is often over-applied to soil near CAFOs because accessible cropland is hard to find and because it is less costly to transport.

On an international level, soils are over-fertilized to the point where the total produce grown on saturated soils cannot utilize all of the nutrients spread on the ground. This over-saturation can lead to excess agricultural storm water run-off or nutrients leaching through the soil. In cases where the primary fertilizer is untreated manure, pathogens from the waste can travel with soil and nutrients into waterways. It has been estimated that this oversaturation of soil leads to 750,000-5 million groundwater-borne illnesses every year.

Even when manure is applied at proper rates and incorporated or injected into the soil, the risk of pathogenic outbreaks is not fully minimized; any farm worker, manure distributor, or a rural resident who comes into contact with the manure will be at risk for contracting the pathogens and diseases carried by livestock. These microorganisms can be transmitted to humans in at least three ways: (1) contaminated meat or crops; (2) farm workers; (3) transportation of animals and/or manure; or, (4) air and water pollution.

Contaminated Meat or Crops

Ensuring that contaminated food does not reach consumers falls under the jurisdiction of the Food and Drug Administration; regular testing for pathogens and contaminants should ensure that tainted foods are kept out of the market. However, every year various foods and food products are recalled when contamination is discovered.

The health and environment in which animals live is the primary factor in whether or not the meat will be contaminated with pathogens and the severity of the infection. Contaminated meat can make humans sick if the meat is not properly handled during meat processing, storage, or preparation. Inadequately cooked or handled meat products can transmit any pathogens the animal carried. Most commonly, meat products will contain:

- Trichinella;
- Cysticercus;
- Salmonella; and
- Listeria.

In addition, crop contamination can also occur when vegetables and grains are fertilized with untreated manure. Crops such as green onions, romaine, and tomatoes have been widely recalled due to contamination by fecal coliforms and/or fecal streptococcus. Generally, incorporation of manure in the fall will not lead to infected crops; however, some strains of viruses and bacteria can linger for months. E. coli 0157:H7, for instance, requires a withdrawal time of 60-120 days to ensure that contamination risks are minimized. Even if manure is not spread during this time, irrigation water that comes into contact with manure or manure spreading machinery can infect the soil and crops.

Farm Workers
Currently, there are roughly 700,000 Americans working in CAFO facilities. These workers are constantly exposed to manure, animal bedding, and toxic gases such as hydrogen sulfide. These workers are also the primary conduit for transmitting pollutants and pathogens from the CAFO to rural residents.

Because farm workers and animal handlers are in regular contact with animals and animal manure, contamination of rural communities often occurs when farm workers do not follow proper manure management and biosecurity protocols. Most pathogens leave the CAFO via worker clothing and shoes. If CAFO workers take clothes home to wash them, wear the same shoes home that were worn in animal pens, and do not shower before leaving the facility they are

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likely carrying manure particles and, therefore, any pathogens that may have infected those animals.

In addition to farm workers, other people who come into contact with the animals and/or animal manure can also transmit pathogens to the community. Animal transporters, equipment technicians and engineers, veterinarians, and visitors to the farm who do not follow careful biosecurity protocols can also spread the disease; because of the nature of visits for the aforementioned visitors, contamination is often more widespread when visiting professionals or tourists do not follow proper manure and animal handling protocols.  

**Transportation of Animals and Waste**

Machinery that is used to haul animals and/or waste can also serve as a vector for pathogen distribution. Trailers, manure tanks, and even personal automobiles can carry pathogens from the CAFO and spread them along the entire route. The most common disease agents found on transportation equipment are:  

- African Swine Fever (ASF);
- Actinobacillus;
- Transmissible Gastroenteritis (TGE); and
- Streptococcus.

These pathogens are usually found in the highest concentration on the parts of the vehicles most often touched, such as door handles, steering wheels, and drink holders. However, any part of the vehicle can become contaminated; contact with animals, animal bedding, manure, wash water, or any other product that has come into contact with the animals can cling to the tires, bottom, or sides of the vehicle.

**Air Pollution**

Pathogens can travel via air to nearby dwellings and buildings. Because the aerosol transmission of pathogens depends on multiple factors, including farm size, pathogen load, pathogen resistance, climatic conditions, and local geography, it is difficult to know how close is too close. Because high-powered fans remove fouled air from CAFOs, it is possible for pathogens to travel far from the barn on these fast-moving winds.

Under the right conditions, pathogens can travel miles from the CAFO via air currents. Mycoplasma hyopneumoniae transmission can span 4.5 kilometers (2.8 miles), porcine reproductive and respiratory syndrome (PRRS) virus can travel 4.5 km, pseudorabies virus can travel 9 km (5.6 mi), and some strains of foot-and-mouth disease (FMD) can travel up to 20 km.

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Because of the distances these pathogens can travel, proper manure management and biosecurity are essential to protect rural communities.

After the recent outbreaks of avian and swine influenza, the air-borne transmission of influenza must also be taken into consideration when calculating safe setback distances, biosecurity protocols, and manure management.

**Water Pollution**

There are many variables that must be incorporated into proper manure management plans and nutrient management plans in order to prevent pathogens from contaminating water resources. Untreated manure can contaminate groundwater, surface water, and wells through multiple pathways:

- Poorly constructed manure lagoons;
- Major precipitation events, flooding, or overflow of manure lagoons;
- Recent application of manure to fields; and
- Atmospheric deposition followed by dry or wet fallout.

Manure can impair water bodies in many ways; nutrient overloads, algal blooms, and chemicals are some of the contaminants that can degrade water quality. However, pathogens pose the biggest public health risk when manure leaches through the soil or runs off into ditches and streams.

Because 42 million Americans utilize groundwater resources from untreated private wells as the primary source of drinking water, pathogens in manure that leach into groundwater sources pose a risk to human health. Wells in rural areas near manure storage facilities and land application sites can become contaminated with E. coli, Cryptosporidium, or any other pathogen that infects nearby livestock. These pathogens can also run off into ditches and rivers, potentially contaminating surface water and reservoirs. In Indiana, many drinking water utilities rely on surface water intakes or reservoirs to supply the resources for urban and suburban drinking water, so the risk of pathogenic infection is not limited to rural residents.

In the draft version of the 2010 Indiana impaired waters list, 822 water bodies were listed as impaired for E. coli. This is a strong indication that untreated manure is contaminating the waters of the state. Though pathogen contamination can come from various sources, livestock manure is a major contributor. This manure can make its way into our waterways through multiple points: spills from manure storage facilities; spills during transportation and land application; spills from staging locations; and agricultural storm water runoff after manure land application.

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Recommendations
Unlike raw human sewage, manure from CAFOs is largely unregulated and untreated. The pathogen content of livestock manure and the potential for disease transmission to human populations must be addressed by the regulatory bodies responsible for manure storage and distribution. Before manure is handled, transported, or spread on fields, it should be tested for pathogen content. This practice will minimize the risk of human contamination and food-borne outbreaks of fecal coliforms and fecal streptococcus.

In addition, best management practices for minimizing pathogen contamination should be incorporated into every manure management plan authorized by regulatory agencies. The following best management practices are encouraged to prevent the spread of disease amongst livestock and transmission to farm workers and nearby residents; by following these guidelines, CAFO operators can successfully prevent the spread of pathogens by farm workers, air pollution, water pollution, and food contamination:

- On-farm sanitation and biosecurity measures;
- Control runoff and leaching from stockpiled manure;
  - Use of vegetative filter strips;
  - Catch basins;
  - Install clean-water diversion;
  - Fencing livestock away from open water;
- Biological Treatment of Manure;
  - Anaerobic storage;
  - Composting;
  - Aeration;
  - Anaerobic digesters;
- Chemical Treatment of Manure;
  - Chlorine;
  - Ozone;
  - Ultraviolet light (UV) irradiation;
  - Pasteurization;
- Land Application;
  - Proper application rates;
  - Consideration of geographical features; and
  - Timing of land application

By incorporating best management practices such as these into the required manure management plans, regulatory agencies will be able to minimize the risk of public health outbreaks and pathogen transfers. Adequate combinations of biosecurity measures, biological and chemical treatment of manure, and land application requirements should be incorporated into the permits and manure management plans for all CAFOs in Indiana.

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Indiana has worked to enact more stringent regulations to protect public health by setting strong E. coli limits for recreational waterways. However, the presence of 822 water bodies impaired for E. coli on the 2010 impaired waters list is an indication that agricultural operations need more education on best management practices to meet this limit. Allowing facilities to self-determine their regulatory status will make it more difficult to conform to the state E. coli standards.

The Hoosier Environmental Council recommends extensive education on best management practices and biosecurity practices to minimize pathogen content in manure before it is distributed as a fertilizer material as well as groundwater monitoring and frequent inspections to ensure that facilities are not discharging. By incorporating enforcement regulations and a penalties schedule into the rules currently under development by IDEM and OISC, livestock operations will have a clear incentive to utilize these best management practices and biosecurity measures to minimize pathogen content.