Is Livestock Manure a Risk to Public Health?

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▪ Introduction

Animal agricultural operations, both confined and non-confined, provide high quality food and non-food products which have a direct economic, nutritional, and cultural benefit to the citizens of North America. Animal agriculture is central to the economic vitality of many of our rural communities. Offsetting these social benefits of animal agriculture are the economic costs and potential public and environmental health risks associated with the storage and disposal of animal manure (excrement and urine).

Whether such risks to the environment or to the public's health culminate into an actual impact is, in my opinion, primarily a function of the quality of management and the design of the operation. Good management of animal wastes and a commitment to cost-effective environmental stewardship can go a long way toward reducing the potential public and environmental health risks associated with the storage and disposal of animal wastes. We cannot design and operate livestock production systems such that the storage and disposal of animal manure carries absolutely zero risk to the environment and to the public's health. However, we should be able to design and operate such systems so that the economic, nutritional, and cultural benefits consistently outweigh the public and environmental health risks associated with animal waste. Our collective challenge is to identify which of the potential risks associated with the storage and disposal of animal wastes are credible threats to public health. The last thing we want to encourage is the wasting of time and money on frivolous concerns.

Our challenge, therefore, is to identify which management practices can reduce these credible risks in an economical but effective manner and to spend the necessary time and money making this knowledge available to and readily adopted by the agricultural community. A variety of potential risks are present in livestock manures (microbes, helminths, nutrients, chemical compounds, etc.), but my article will focus only on microbial risks since this my area of expertise. Is livestock manure a risk to the public health?

There is no simple answer to this question since in many cases the risk can be significantly reduced based on good management practices and effective storage and manure management plans. In other cases, poor management or poor design of storage facilities or negligent disposal practices can create unreasonable public health risks through the contamination of commodities such as food and water.

Considerable knowledge is already available for designing manure management plans and cropping systems for handling the nutrient loads in livestock manure. Our knowledge base for managing microbial risks from livestock manure is incomplete and in need of more research. For example, designing cropping systems for land application of manure slurries so as to minimize microbial hazards is poorly understood. In addition, and perhaps most importantly, we have a poor understanding of which of the potential microbial risks associated with the storage and disposal of animal wastes are credible threats to public health. For example:

- Is *Giardia* shed in the excrement of swine infectious for humans under normal circumstances, and if so, does storage of the manure in a lagoon inactivate or remove the *Giardia* cysts?
- Is the swine roundworm, *Ascaris suum,* a credible health risk for humans?
- Is land application of swine manure a significant risk factor for human waterborne infection with *Erysipelothrix rhusiopathiae*?

Although we still have much to learn regarding microbial public health risks associated with the storage and disposal of swine manure, I would argue that common-sense management and well-designed facilities can minimize much of the microbial risk associated with pork production.

Critical Control Points

Pathogens from swine manure can infect humans through a variety of routes. Almost all routes require some form of contact with infective swine manure (manure containing infectious pathogens) with the commodity or entity of concern. For example, human infection could result from direct exposure of humans to infective manure, such as occupational exposure of farm employees, veterinarians, or slaughterhouse employees. Microbial risks can occur if humans ingest water which has been contaminated with infective swine manure, or if humans ingest unprocessed foods such as fresh vegetables which have been irrigated with water contaminated with infective swine manure or effluents. Microbial food-safety risks can occur when slaughtering methods inadvertently contaminate the carcass with infective fecal material and the pathogen succeeds in surviving further processing, packaging, and distribution, with the final step being that the pork product is inadequately cooked by the consumer.

Variations within each of these routes of exposure can occur, but the main point is that each route has strategic points where the pathogen is vulnerable to removal or inactivation and thereby we have an opportunity to minimize the risk of transmission. These points, as has been discussed in the food safety and animal husbandry literature, are referred to as “Critical Control Points.” Four primary steps need to occur for waterborne transmission of pathogens from swine manure to humans. Eliminate any one of these steps and transmission of the specific pathogen from swine to humans through water can be significantly reduced or even stopped completely.

- The pathogen must be excreted by livestock.
- The pathogen must reach a water supply either by the animal defecating in water, by overland flow (e.g., runoff from a site which has swine or has been spread with manure during rainfall, snowmelt, etc.), by subsurface flow (e.g., poorly sealed manure lagoons or from agricultural land receiving manure), or by some combination of these three pathways.
- The pathogen must retain the cellular functions necessary for initiating a new infection in humans during the time it is in the environment. Many pathogens are poorly equipped for survival in the environment and prolonged exposure to heat, freezing, especially repeated freeze-thaw cycles, or drying can rapidly kill most of the pathogens of concern. Some, such as the eggs of *Ascaris suum,* are very hardy and can remain infective for many months in cool wet conditions.
- Given that the pathogen is shed by swine, reaches a water source, and remains infective until ingested by a human, the concentration of infective pathogens must be sufficiently high in order to initiate an infection. The minimum number of pathogens needed to initiate infection varies from pathogen to pathogen. For example, the protozoal parasites, *Cryptosporidium parvum* and *Giardia lamblia*, have a very low infectious dose. In contrast, for bacteria such as *Campylobacter jejuni* or *Salmonella typhimurium*, hundreds or thousands need to be ingested in order to initiate an infection.

▪ Potential Pathogens Associated With Swine Manure

The following is a brief list of some of the microbial and helminth pathogens that may, under certain circumstances, be transmitted to humans as a fecal-oral pathogen. I have included only some of the potential pathogens associated with swine manure. The scientific data supporting the role of swine as an important source of human infection or as causing unacceptable levels of human disease is very weak for several of these pathogens, but much stronger for several others.

Protozoa

Pathogenic protozoa with a feasible swine component should include at a minimum *Cryptosporidium parvum* and *Giardia duodenalis.* Both of these protozoa are shed by a wide range of mammals, including humans, domestic animals, and wildlife. The principle features of these protozoa are:

- The infectious stages of *Cryptosporidium parvum* (the oocyst) and *Giardia duodenalis* (the cyst) do not reproduce outside the host,
- An apparently low infectious dose is necessary to initiate an infection in humans,
- The cysts and oocysts are relatively resistant to chemical disinfectants.

Considerable controversy surrounds the issue of whether *Giardia duodenalis* cysts obtained from livestock, including swine, can readily infect humans. *Balantidium coli*, a ciliated protozoan found in the intestines of humans and commonly in pigs, appears to be a rarely reported human disease in North America. Its potential to be transmitted from pigs to humans remains controversial in the scientific literature. *Entamoeba polecki* is a poorly understood protozoal pathogen that can colonize swine and appears uncommon among humans in North America. Much of the data for *Balantidium coli* and *Entamoeba polecki* has been generated in tropical systems and in localities where humans live in direct contact with pigs, a situation uncommon for most North American citizens. Whether *Balantidium coli* and *Entamoeba polecki* represent a credible public health threat in North America, either through food, water, or occupational risk, is certainly open to scientific debate.

Bacteria

There are several species of bacteria that can be shed in the excrement or urine of swine that are infectious for humans. Most notable is *Salmonella cholerasuis*, *Yersinia enterocolitica*, *Erysipelothrix rhusiopathiae*, *Campylobacter jejuni*, *Streptococcus suis*, *Brucella suis*, and *Leptospira* (shed in urine). Swine are considered primary reservoirs for many of these, with infected pigs often not showing any sign of infection (e.g., *Yersinia enterocolitica*). Although evidence exists for food-borne and direct-contact routes of exposure for humans, the evidence for documented waterborne transmission of many of these bacteria from swine operations to humans is lacking. To be fair and impartial, scientific evidence to prove that waterborne transmission from swine operations to humans is not occurring is equally lacking. The primary problem is that when a waterborne outbreak occurs, it is typically very difficult to determine the source of the contamination by the time public health officials become aware of the problem. With the development of more sophisticated molecular tests, sources of waterborne bacteria will likely become easier.

The arguments regarding swine manure lagoons as a reservoir of waterborne bacterial pathogens are ongoing in the United States, with federal legislation for confined animal feeding operations now being put into place which will more carefully regulate the operation and waste disposal of such facilities. Now is the time to develop effective quality assurance programs which not only reduce bacterial infections within swine populations, but to develop and implement manure management practices which reliably inactivate the majority of pathogenic bacteria in waste effluents.

Viruses

At this time there is conflicting evidence that the group of viruses shed in the excrement of North American swine are infectious to humans. While some virologists feel credible evidence exists, many veterinary virologists believe credible evidence is lacking. Although interspecies transmission of rotaviruses has been demonstrated experimentally, the role of livestock-derived rotaviruses in the epidemiology of human infection is unclear. Although influenza virus from swine appears to be infectious for man, the route of transmission does not typically involve swine excrement.

Helminths

Many of the parasitic worms, or helminths, which are present in swine and infectious for humans, are transmitted not through swine excrement, but through contaminated meat. The classic example is *Trichinella spiralis*, which has been the focus of successful disease control efforts in much of the developed world, and *Taenia solium*, in which humans are the definitive hosts. Modern, commercial swine raising facilities typically prevent swine from coming into contact with human excrement, effectively breaking the cycle of *Taenia solium* between swine and humans.

What about helminths shed in the excrement of North American swine? It has been suggested that the eggs of the swine roundworm, *Ascaris suum*, are capable of infecting humans. Successful infections were initiated in human volunteers which had ingested *Ascaris suum* eggs, so it is reasonable to assume that some level of transmission could occur if humans are accidently ingesting food or water containing infective eggs. *Ascaris suum* eggs are known to survive long periods of time under moist conditions. Although we do not have reliable estimates for how many cases of human ascariasis are attributable to swine manure, it may be prudent to include in our quality assurance programs effective deworming practices that control this parasite.

▪ Conclusion

Although pathogens exist in swine manure which can infect humans under appropriate circumstances, there are a wide variety of ways to intervene and help minimize the public health risks associated with swine manure. Quality assurance and environmental stewardship programs are being rapidly developed by a variety of organizations, both in the public and private sector. In addition, much research is underway to determine which management practices will yield the greatest benefit-to-cost ratios toward enhancing food safety and minimizing environmental risks.

One of the first options for intervention is to reduce on-farm pathogen levels during the various stages of pork production. Strategic manure handling practices and improvements to the design of manure storage facilities can increase the inactivation rates of pathogens shed in swine manure. Improved slaughtering procedures will undoubtedly help minimize fecal contamination of carcasses. Occupational exposure to swine pathogens can be reduced by such methods as the wearing of appropriate protective clothing and gloves, chemical disinfection of boots, and the cleaning of hands prior to eating or returning home from work. Many of these practices are already standard operating procedures within the industry. In the meantime, we should proceed carefully and without assumption on how to control these manure-borne pathogens and always insist that public policy on such matters as livestock impacts on water quality is grounded in good science.