Pathogen Export from Grassland Systems

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**PATHOGEN EXPORT FROM GRASSLAND SYSTEMS**

*Phil Hobbs, Dave Davies and Phil Haygarth*

Pathogens are living micro-organisms that can cause disease and sub-clinical effects. Pathogenic organisms come from different sources and can be listed as bacteria, fungi, viruses, protozoa or algae. In farm animals, generic *Escherichia coli* are virtually always present in their digestive tract and waste products, but these are almost entirely harmless. However, new strains of organisms are continually evolving; *E. coli* O157:H7, for example, is a particularly virulent strain of bacteria that can cause stomach cramps, bloody diarrhoea, and occasionally kidney failure and death in some people. Only a few ingested cells of *E. coli* O157:H7 are necessary to cause illness. The origins and pathways of pathogens from livestock sources are complex and unclear, but contamination during slaughter and butchering and during food processing and preparation has proved to be the source of some disease outbreaks. Contamination of water used for drinking, bathing or crop irrigation may be another source. In this article we outline our current research and, in particular, consider the effects of manure spreading and transfer into watercourses.

### Pathogens in livestock ecosystems

Micro-organisms constantly mutate to produce new variants whose origins are difficult to determine. Once in existence, potential transmission pathways of pathogenic organisms throughout agricultural systems are indicated in Figure 9.1, which also indicates the routes to human populations, or back to livestock.

Infection by a disease can be by ingestion with food or water, or as particulates trapped in the nasal region or upper airways that are swallowed. Infectivity can also occur by particulates transporting pathogens into the lungs. Pathogens may also transfer to edible crops or drinking water sources after spreading manure on adjacent land.

### Pathogens in the digestive tract of farm animals

The control of human pathogens in the farm animal has to be a key critical target to reduce human illness. The reason for this is that animals act as a reservoir for the contamination of meat and dairy products, and they are also a source of contamination of water, air or simply dung in areas used for recreation (Figure 9.1). Animals harbouring pathogens such as *E. coli*, *Campylobacter*, *Listeria* and *Salmonella* are generally unaffected and are healthy. In fact, some of these human pathogens are actually beneficial to the farm animal as they supply the animal with essential nutrients such as vitamins by synthesis in the gut. However, an infected animal can produce in excess of 1 million human pathogenic bacteria for every gram of dung they produce (equivalent to about 4 x 1010 bacterial cells per day). A conservative estimate is that 700 pathogen cells could cause illness in humans.
These human pathogenic populations are resident at various points along the ruminant gut where they adhere and multiply. *E. coli*, for example, are known to have the ability to reproduce in the rumen and in the hindgut. Research at IGER is beginning to focus on methods of controlling human pathogen populations in the live animal. For example, diet could have a role in influencing pathogen survival in the animal gut. Feeding maize silage has been associated with significantly higher levels of *E. coli* 0157 in faeces than with other forages. Conversely, studies abroad have inferred that diets containing red clover may have the potential to reduce pathogen loads in cattle. Laboratory studies at IGER have indicated that natural plant extracts from red clover have the ability to inhibit the growth of a number of pathogens on agar plates, including *E. coli* (Figure 9.2). Further studies are continuing along two lines: 1) to establish whether this effect can be transferred within the farm by utilising red clover as part of the animal feed; and 2) to identify the active plant constituent in the bio-control of the pathogen.

**Aerosol transmission by land spreading manure**

Beef and dairy cattle spend some time in housed conditions where it is necessary to collect manure and urine for later disposal. IGER scientists have been conducting experiments to determine the spread of micro-organisms by wind dispersal during slurry spreading using a conventional splash plate spreader. A number of factors are relevant to the dispersal and survival of micro-organisms: the size of aerosol particles created during spreading; wind speed; atmospheric conditions which affect drying rate and ultra-violet radiation. The recent environmental history of the pathogen is also important. For example, organisms that have previously been exposed to drying and rewetting will be more likely to survive aerosol travel, and often exhibit increasing pathogenic capacity than those that have been grown in laboratory conditions.

Early results have shown that spreading of livestock slurry provides a great chance of pathogen transfer on the wind (Figure 9.3). The data show the concentration of enteric bacteria, which are used as indicators of faecal organisms, downwind of the splash plate spreader. Spreading is not uniform and at the end of the load fine particles are blown out of the spreader producing a visible aerosol plume as shown in Figure 9.4. Even in light winds (4.2 m per s, or 9 mph) the transfer of 5-20 micron diameter particles would be up to 200 m and represents about 10% of the original emission. However, particles will desiccate and become lighter as they travel in the air. This will increase the distance they can travel but also reduces the chance of micro-organisms remaining viable.
Transmission of pathogens to watercourses

Perhaps the most efficient and worrisome export pathway is the transport of pathogens from land to water, with direct contamination of streams, rivers and bathing waters. Pathogens are especially vulnerable to transfer 1) when rainfall and runoff occur after application of infected manure, and 2) in the presence of infected animals grazing the system. Studies at IGER found that once infected animals are removed from grazing, the risk of transfer to water is reduced, and declines through the ensuing few months. However, as we show in Figure 9.5, concentrations of *E. coli* were still significant (at over 400 colony forming units (CFU) per ml) even some 40 days after cattle were removed from land.

*Figure 9.3 Transmission of indicative micro-organisms from a splash plate spreader. The concentration of organisms in the slurry was 31,000 colony forming units (CFU) per ml. Wind speed was 4.2 m per sec, and humidity was 90%.*

*Figure 9.4 Blow out or spray plume from a splash plate spreader at the end of the slurry load.*
We have also been able to develop some simple rules about the circumstances of pathogen export from grassland to water. First, we have found that export tends to occur during periods of high rainfall and that there is a strong correlation between pathogen numbers and runoff volume on the poorly drained soil at North Wyke. Second, there is also a strong correlation between the movement of pathogens and turbidity of water. This means that pathogens are attached to, or in close association with fine particles and colloids from grassland as they move to water.

Conclusions
Pathogens are able to mutate to produce new pathogenic strains that enter the ecosystem and can travel through pathways to the human population involving air, water, or food. It is clear that livestock act as reservoirs for pathogen contamination of the ecosystem and the human food chain. IGER’s future efforts will be examining natural plant- and microbial-based methods for controlling the growth of the pathogenic bacterial populations in the gut of ruminants to reduce the load of pathogens being excreted, and in further determining pathways of transfer. IGER has shown that the application of manure to land leads to potential pathogenic infection. Infection may occur by transfer through the air within aerosols to adjacent edible crops or waterways. Also, waterways may be directly contaminated by run-off from the surface or leaching through the soil after land spreading of livestock manure. IGER will develop the relationship of survival characteristics between pathogens and selected marker organisms that can be used in the environment to improve interpretation and experimental methodology.

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