3.11 Microbial risks

Dairy wastewater, both raw and treated, contains pathogens that may reinfect the herd or, in some cases, cause disease in humans. Proper management during reuse and the use of exclusion periods before grazing are necessary to prevent infection.

Pathogens of relevance to the dairy industry

Faecal and other wastes (urine, respiratory secretions, sloughed skin etc.) collected by waste management systems contain large numbers of pathogens (disease-causing microorganisms). Such pathogens can cause diseases in animals grazing on the pasture or crops to which manure and effluent have been applied, and to humans via occupational exposure, or via exposure to contaminated water, food, air or soil. The term ‘zoonoses’ is used to describe those microorganisms of animal origin that can cause diseases in humans.

The list of pathogens found in dairy shed wastewater is long; detailed descriptions are given by Pell (1997) and Sobsey *et al.* (2006). In summary, pathogens can be grouped into viruses, bacteria, fungi and parasites (protozoa and helminths).

Pell (1997) nominated the pathogens of most concern to the US dairy industry as *Salmonella* spp., *Escherichia coli*, *Listeria monocytogenes*, *Mycobacterium paratuberculosis*, *Cryptosporidium parvum*, and *Giardia* spp. as a result of confirmed or suspected links to outbreaks of disease in humans. Houlbrooke *et al.* (2004) reported *Campylobacter jejuni* to be the principal bacterial hazard for drinking water and recreational water users in New Zealand. Table 1 summarises the characteristics of these pathogens.

Table 1. Pathogens relevant to the dairy industry (Sobsey *et al.* 2006).

	Pathogen	Disease in dairy cattle	Disease in humans	Transmission
Bacteria	*Salmonella* spp.	May be asymptomatic	Yes	Food, water, and clothing
	Escherichia coli	No	Yes (pathogenic strain O157:H7)	Food and water
	Listeria monocytogenes	May be asymptomatic	Yes	Food, water, and clothing
	Mycobacterium paratuberculosis	Yes (Johne’s disease)	Uncertain (possible link to Crohn’s disease)	Respiratory
	Campylobacter jejuni	No	Yes (gastroenteritis)	Food and water
	Leptospira spp.	Yes	Yes	Urine
Protozoa	*Cryptosporidium parvum*	May be asymptomatic	May be asymptomatic	Ingestion of water
	Giardia spp.	May be asymptomatic	May be asymptomatic	Ingestion of water

Longhurst *et al.* (2000) measured faecal coliform concentrations of 3×10^5 to 1.6×10^6 g^{-1} in untreated dairy shed effluent in New Zealand, and Wang *et al.* (2004) recorded 1.2×10^7 cfu·g^{-1} from fresh dung. Ross and Donnison (2003) found *Campylobacter jejuni* at 10^5 to 10^6 organisms per 100 mL in untreated effluent and 10^3 organisms per 100 mL in a storage pond in New Zealand.

Pell (1997) states that young animals are the most likely animals in a herd to be infected with the range of pathogens listed in Table 1.

Effects of treatment, storage and reuse on pathogen survival

Pathogen numbers can be reduced by two processes: inactivation (e.g. by heat during composting), physical removal or both (e.g. die-off in ponds and sedimentation to pond sludge). Separated solids and sludge must be considered as a source of pathogens during desludging and reuse.

Although there is a body of research into pathogen survival in municipal wastewater treatment, the efficacy of animal wastewater management systems at reducing pathogen viability requires more research. However, Sobsey *et al.* (2006) suggest that:

- *Salmonella* can be detected in liquid manure after 140 days at 10 °C, and *Listeria* after 106 days during winter (durations longer than the hydraulic residence time of some pond systems)
- anaerobic ponds at piggeries may reduce bacterial and viral indicator organisms by 1 to 2 log (90%–99%), but faecal coliform concentrations of ~100 000 cfu per 100 mL remain
- pond efficacy is not consistent and is affected by ambient temperature
- pathogen reduction is consistently improved by the use of multiple ponds in series rather than one large pond of the same volume (minimising short-circuiting)
- pathogen reductions following land application are ‘highly variable and largely unknown; potentially high’.

Generally, pathogen numbers are reduced by sunlight (UV radiation), drying, high temperatures, and high or low pH. Pathogen viability, or more importantly die-off, depends on climate and is therefore difficult to pinpoint. In addition, under given conditions, different pathogens have varying levels of resistance to environmental stresses. Guan and Holley (2003) suggest that the time required for pathogen numbers to return to background levels under dark incubation conditions ranged from 3 days (*Campylobacter*) to 56 days (*E. coli*) under warm conditions (20–37 °C), and longer under cold conditions.

Some factors are contradictory. Although rainfall favours bacterial survival, it may also physically remove (wash) the residues of effluent from the vegetation before any subsequent grazing and reduce the likelihood of ingestion and infection. Vegetation density and height also determine the microclimate into which the pathogens are placed upon reuse.

Composting provides a process-oriented approach to pathogen control. Excepting thermophilic microorganisms, pathogens cannot withstand temperatures above 55 °C for an extended period of time. Composting is therefore particularly effective in reducing pathogen viability in manure solids where all parts of the compost pile are heated. AS 4454 (Standards Australia 2003) recommends achieving 55 °C for a minimum of 3 consecutive days. However, as the outside of the pile remains cooler than the inside, US-based composting standards require a minimum of 15 days in a windrow turned five times for pathogen control.

Given the range of manure storage and treatment practices available to farmers, it is advisable to assume that a significant number of organisms remain viable at reuse and are applied to crop or pasture, and that a withholding or exclusion period is needed to prevent repeated herd infection (see below).

Management practices to reduce risks to stock

Drying, solar radiation and competition from soil bacteria following the application of animal wastes to soil and vegetation can all greatly reduce pathogen populations. However, without proper management, there is significant potential for pathogens to cause disease in grazing stock. Although cattle avoid grazing immediately around dung pats, they have little choice about where effluent has been uniformly applied.

Recommendations contained in existing state-based guidelines generally include the following strategies:

- Apply wastewater thinly and uniformly to recently grazed pasture so that pathogens can be exposed to maximum sunlight and desiccation.
- Exclude cattle from the reuse area for 2 to 5 weeks.
- Do not apply effluent to paddocks on which stock <12 months of age will graze.

Exclusion periods of 2 to 3 weeks are supported by New Zealand research. Longhurst *et al.* (2000) applied 14 mm of untreated wastewater (equivalent to 25 kg N ha^{-1}) to plots at intervals of 25, 20, 15, 10 and 5 days before grazing. Although faecal coliform counts on pasture had decreased to background levels by 10 days, cows offered a 'taste panel' of plots showed a dislike for pasture treated within the previous 10 days. There was no significant difference between the control and treated pastures at 15 days, but Longhurst *et al.* (2000) recommended a minimum exclusion period of 20 days to maximise intake.

It is clear that some pathogens may still be present at higher-than-background levels after the exclusion period depending on environmental conditions after spreading. However, vegetation growth over that period should minimise the ingestion of soil with any remaining pathogens.

Further information specific to the prevention of Johne's disease can be found at http://www.dairyaustralia.com.au/content/view/273/257/. Two of the recommendations are relevant to effluent management:

- **'Management of the calf rearing area should ensure that no effluent from animals of susceptible species come[s] into contact with the calf.'**
- **'Calves up to 12 months should not be reared on pastures that have had adult stock or stock that are known to carry BJD [bovine Johne's disease] on them during the last 12 months.'**

Contractors should ensure that all equipment that has been in contact with effluent and manure is thoroughly cleaned before leaving the farm.

Aerosols

Pathogens may be transported away from the reuse site on aerosols. The likelihood of such bioaerosols causing human infection is difficult to quantify owing to the variable size of aerosols and weather conditions affecting both the transported distance and pathogen survival. Sobsey et al. (2006) summarises a small number of research papers by stating that insufficient research has been conducted to quantify the risk that effluent reuse poses to nearby residents.

Environmental guidelines for the pork industry (Australian Pork 2006) suggest that 'relatively small separation distances (e.g. 125 m at wind speeds of 0.5 $m{\cdot}s^{-1}$ and 300 m at wind speeds of 2.5 $m{\cdot}s^{-1}$) were needed to minimise any health risks from campylobacter and salmonella in the irrigation aerosols.'

OH&S implications

Given the likelihood that some zoonoses will remain in effluent at the time of reuse, operators and staff must observe appropriate hygiene practices (see chapter 6 'Occupational health and safety').

References

Australian Pork 2006, ‘National Environmental Guidelines for Piggeries’, APL, Canberra.

Guan, T.Y. & A. Holley 2003, ‘Pathogen survival in swine manure environments and transmission of human enteric illness—a review’, *Journal of Environmental Quality,* 32, 383–392.

Houlbrooke, D.J., D.J. Horne, M.J. Hedley, J.A. Hanly & V.O. Snow 2004, ‘A review of literature on the land treatment of farm-dairy effluent in New Zealand and its impact on water quality’, *New Zealand Journal of Agricultural Research,* 47(4), 499–511.

Longhurst, R.D., M.B. O’Connor, K. Bremner & L. Matthews 2000, ‘Animal constraints to pasture treated with dairy farm effluent: preference under grazing and issues of faecal contamination’, *New Zealand Journal of Agricultural Research,* 43, 501–507.

Pell, A.N. 1997, ‘Manure and Microbes: Public and Animal Health Problem?’ *Journal of Dairy Science,* 80(10), 2673–2681.

Ross, C. & A. Donnison 2003, ‘Campylobacter and farm dairy effluent irrigation’, *New Zealand Journal of Agricultural Research,* 46, 255–262.

Sobsey, M.D., L.A. Khatib, V.R. Hill, E. Alocilja & S. Pillai 2006, ‘Pathogens in animal wastes and the impacts of waste management practices on their survival, transport and fate’, Pp. 609–666 in Animal Agriculture and the Environment: National Center for Manure and Animal Waste Management White Papers. J. M. Rice, D. F. Caldwell, F. J. Humenik, eds. 2006. St. Joseph, MI, USA, ASABE.

Standards Australia 2003, *Composts, soil conditioners and mulches*, Australian Standard 4454–2003, Standards Australia, Sydney.

Wang, L., K.R. Mankin & G.L. Marchin 2004, ‘Survival of fecal bacteria survival in dairy cow manure’, *Transactions of the ASAE,* 47(4), 1239–1246.