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<th><strong>Title</strong></th>
<th>Aerosol dispersal of cattle slurry on holdings restricted due to bovine tuberculosis</th>
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<td><strong>Authors(s)</strong></td>
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<tr>
<td><strong>Publication date</strong></td>
<td>1996-07</td>
</tr>
<tr>
<td><strong>Series</strong></td>
<td>Selected Papers, 1995</td>
</tr>
<tr>
<td><strong>Publisher</strong></td>
<td>University College Dublin. Centre for Veterinary Epidemiology and Risk Analysis</td>
</tr>
<tr>
<td><strong>Item record/more information</strong></td>
<td><a href="http://hdl.handle.net/10197/8978">http://hdl.handle.net/10197/8978</a></td>
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Introduction
The continuing problem of tuberculosis in cattle in Ireland has raised questions concerning the possible role of farm practices, including the management of manure, in the spread of this disease. Cattle numbers in Ireland have increased considerably since the programme for the eradication of tuberculosis in cattle commenced. The housing of large numbers of cattle during the winter months has increased the quantity of manure especially slurry which is spread on farmland. Intensification has led to husbandry and management changes. Whereas formerly hay was fed to cattle in straw bedded sheds, currently cattle are commonly overwintered either in cubicle or slatted floored houses and fed silage. These changes have resulted in a considerable increase in the volume of slurry spread on farmland.

Many bacteria including *M. bovis* (Maddock, 1936; Makkavenskaya, 1939 and Reuss, 1955) may be excreted in faeces and can survive for a considerable period in slurry and solid manure. Solid manure, however, is not generally considered to be a major factor in the spread of disease as it is normally stacked and composted for many months before landspreading. In addition, landspreading of solid manure does not normally result in the production of aerosols. In contrast, slurry cannot be composted and consequently bacteria may survive in it for longer periods than in composted manure. Reported survival periods of bacteria in slurry include *Mycobacterium bovis* for 176 days (Dokoupil, 1964), *Brucella abortus* for 240 days (Verger, 1981) and *Salmonella typhimurium* for 209 days (Best *et al.*, 1971). The land application of slurry generally results in the production of aerosols which can drift downwind for considerable distances particularly in breezy conditions (Evenden, 1972; Tamasi, 1983 and Boutin *et al.* 1988). Slurry contamination of water and pasture has been associated with the occurrence of a number of diseases in cattle including brucellosis (Hoflund, 1961) and salmonellosis (Jack and Hepper, 1969).

Disinfection of slurry with a number of different chemicals has been reported including xylene (Plommet and Plommet, 1974), calcium hydroxide (Thunegard, 1975) and formalin (Ley, 1992).

A study was undertaken to investigate the extent to which slurry contaminated with *M. bovis* might be a source of infection in Irish farms, and, if so, what means were available to prevent such spread.
A summary of these investigations is presented in this paper.

**Aerial Dispersal of Bacteria**

The dispersal and recovery of a marker bacterium, *Serratia rubidaea*, added to cattle slurry and used as a proxy for *M. bovis*, was investigated using five slurry spreading methods under field conditions. Plates containing MacConkey agar were placed on the ground downwind from the slurry spreaders to recover the marker bacteria. The maximum distances marker bacteria were recovered downwind following dispersal by shallow injection, band, low splash plate, high splash plate and raingun spreading methods were 50m, 50m, 200m, 300m and 800m, respectively. The relationship between weather variables and bacterial dispersal in this investigation was limited. There was a positive association (p < 0.1) between windspeed and the maximum distance marker bacteria were recovered from the injection and raingun spreaders. A positive association (p < 0.05) between windspeed and the numbers of marker bacteria recovered 100 metres and 200 metres downwind from the raingun was demonstrated. In the case of the high splash plate spreader there was an association (p < 0.1) between windspeed and the number of marker bacteria recovered at 100 and 200 metres downwind. No consistent association was shown between bacterial dispersal and relative humidity, air temperature or sunlight.

**Chemical Inactivation of *M. bovis***

In a laboratory experiment, *M. bovis* added to cattle slurry was inactivated by the addition of both calcium hydroxide powder (20 kg/m³) and a mixture of calcium hydroxide and water termed "thick lime milk" at two concentrations (equivalent to 11.25 and 20 kg/calcium hydroxide /m³). Inactivation of the mycobacteria occurred within 24 hours with "thick lime milk" treatment while calcium hydroxide powder required up to 48 hours to achieve inactivation of these microorganisms. Slurry pH increased from its original pH of 7.3 to a value over 12.0 following the addition of "thick lime milk".

**Application of Treated Slurry to Grass**

The effect of the application of cattle slurry treated with calcium hydroxide powder and "thick lime milk" on grass dry matter yield, grass composition and silage quality was investigated in a series of field experiments. Neither treatment had a serious adverse effect on grass composition or silage quality. However, these treatments significantly reduced grass dry matter yield (p < 0.05) when compared with grass to which untreated cattle slurry was applied. Slurry pH increased from approximately 7.3 to a value over 12 in most instances.

Slurry in cattle sheds on two farms was treated with calcium hydroxide powder (24.5kg/m³) and "thick lime milk" (17.7kg calcium hydroxide/m³). In each case the slurry pH increased to a value above 12.0, but this high pH value was more effectively maintained in slurry treated with "thick lime milk".

**Conclusions**

This study confirmed that slurry from cattle with infectious disease presents certain risks, particularly in windy conditions, if spread without observing a sufficiently long storage time.

The stipulated minimum storage period of two months for manure on tuberculosis-restricted farms in Ireland may be adequate in the case of solid manure but is too short for contaminated slurry. A storage period of six months may be more appropriate for slurry from infected farms. The treatment of slurry with either calcium hydroxide powder or "thick lime milk" may be an...
alternative measure on farms where tuberculosis occurs and slurry storage capacity is limited. However, this approach involves a financial outlay and, furthermore, it may result in reduced grass yields in the short term. The spreading of slurry on arable land or grassland on which silage is to be harvested reduces the risk of cattle contracting infection while grazing, and such a practice should be followed when in doubt.

Spreading slurry in calm weather reduces the risk of aerosol drift. This study demonstrated that the spreading method employed can determine the extent of slurry dispersal. Accordingly, the use of a raingun to spread slurry likely to contain pathogens is a potentially hazardous procedure, particularly for adjacent farms, while the shallow injection and band spreading methods minimise the risk of aerosol drift to adjacent grazing areas. The slurry spreading methods which minimise bacterial dispersal can also limit slurry smell in the vicinity and downwind.

The presence, number and duration of survival of *M. bovis* microorganisms in slurry from cattle herds with tuberculosis requires thorough investigation. The fact that cattle slurry may contain many pathogenic bacteria, including salmonellae and leptospires, which are infectious for both animals and man highlights the need for education of herd owners on the risks arising from slurry spreading. Appropriate legislation specifying longer storage periods for slurries on controlled holdings should now be considered, in order to minimise the risks to human and animal health which may arise from this source.

**References**


