

The effect of incorporating slurries on the transport of faecal coliforms in overland flow

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Abstract. Rainfall simulation experiments on a laboratory soil flume were conducted to test the hypothesis that the incorporation of slurry into the soil would reduce bacterial transport in overland flow. Presumptive faecal coliform (PFCs) concentrations were higher in the runoff from the surface applied treatment than from the incorporated treatments. The transport of PFCs and organic sediment were strongly correlated, with values of r ranging from 0.72 to 0.91.

Keywords: Slurry, faecal coliforms, pathogen transport, overland flow, slurry management, diffuse pollution

INTRODUCTION

About 90 million tonnes of livestock slurry and manure are produced annually in the UK (Smith *et al.* 2001). This presents a bacterial pollution risk to surface waters, so managing the application of slurries and manures to soils is of importance to prevent the bacterial contamination of surface waters.

Overland flow is an important pathway for the transport of bacteria to surface waters (Reddy *et al.* 1981). However, we could find no studies in the literature investigating whether incorporating surface applied slurries would reduce transport. To fill this gap, we carried out soil flume experiments to test the hypothesis that the incorporation of slurries will lead to a reduced number of bacteria being detached and transported over the soil surface.

MATERIAL AND METHODS

The study was performed in the laboratory using a soil flume, set at a 5% slope, filled with a sandy loam textured soil of the Cottenham series (Lamellic Ustipsamment, Soil Survey Staff 1999). The flume was 2.5 m long, 1 m wide (across slope) and 30 cm deep. Simulated rainfall was applied at an intensity of 70 mm h⁻¹ within 24 h of the slurry application.

Cattle slurry was applied to the soil at a rate of 30 t ha⁻¹ (7.5 kg per plot) and either left on the surface or thoroughly

mixed with the soil (incorporated). The dry solids content of the slurry ranged from 8% to 24%. All results are expressed on a dry weight basis of slurry.

Three replicates were run for each treatment. The organic matter content of the sediment was determined by loss after ignition in a furnace at 550°C for 4 h and the mineral sediment concentration by difference. One aliquot of each runoff sample was analysed for presumptive faecal coliforms (PFCs) in triplicate following serial dilution by membrane filtration (APHA 1992).

RESULTS

Statistical analysis using the Kolmogorov–Smirnov test revealed that there was no significant difference ($P < 0.1$) between the mean total runoff volume from the incorporated and surface applied plots (Table 1). The total mass of mineral sediment transported was greatest in the incorporated treatment, whereas the total mass of organic sediment transported was greatest in the surface applied treatment (Table 1). These differences between the concentrations of mineral and organic sediment in runoff from the two treatments were significant at the $P < 0.1$ level.

Figure 1 shows the changes in the ratio of the number of faecal coliforms 100 mL⁻¹ runoff to the number of faecal coliforms per gram of dry slurry over time. This analysis suggests that faecal coliforms were very mobile in the first 15 min of the surface applied experiments but that this rate of transport declined rapidly as the simulation progressed. Faecal coliforms were much less readily transported in runoff from the incorporated treatment, and a gradual decline in the rate of faecal coliform transport was observed throughout the duration of the experiment.

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Table 1. Mean total runoff, mineral and organic sediment loss from the incorporated and surface applied slurry treatments during a 45-min sampling period \pm standard deviation.

	Incorporated	Surface
Mean total runoff (L)	105 \pm 7	101 \pm 10
Mean total mineral sediment eroded (g)	1023 \pm 546*	148 \pm 29*
Mean total organic sediment eroded (g)	126 \pm 20*	199 \pm 20*

*Indicates significant difference ($P < 0.1$).

DISCUSSION

Surface application of slurry led to higher concentrations in runoff of both organic sediment and PFCs, as the surface applied slurry was exposed to the erosive forces of rainsplash and overland flow. Conversely, mineral sediment erosion was suppressed when slurry was applied to the surface. This is probably explained by the protective effect that the layer of slurry had on the soil surface. The results corroborate our initial hypothesis that the incorporation of slurry will reduce the numbers of PFCs transported by reducing the number of organisms exposed to detachment processes.

The logarithm of faecal coliform concentrations and organic sediment concentrations in runoff were correlated at the $P < 0.05$ level in two of the three replicates. However, there was substantial variation between experimental runs in the values of the slope and intercept of the regression lines, and the factors responsible for this variation have not yet been identified

CONCLUSIONS

While our findings clearly show that incorporation of slurries reduces the transport of faecal bacteria from soils under laboratory conditions, in the field this may not always be the case. Microorganisms in surface applied material will potentially be subject to die-off caused by desiccation and exposure to ultraviolet light. Nevertheless, we believe that where possible, slurries and manures should be incorpo-

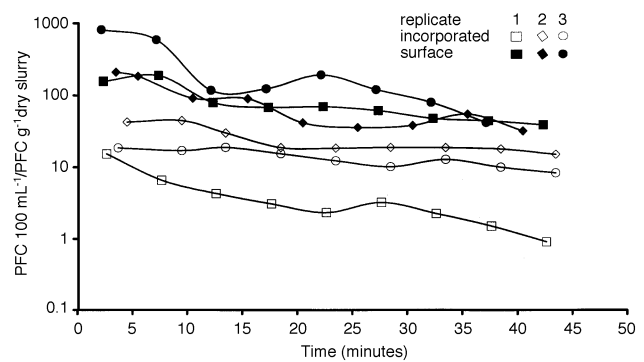


Figure 1. Normalized presumptive faecal coliform concentrations measured in runoff from a 1 x 2.5 m soil flume under simulated rainfall at 70 mm h⁻¹ for the incorporated and surface applied slurry treatments.

rated, since this reduces the risk of movement in overland flow, thus reducing the risk of water pollution.

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