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TILLAGE SLOWS FECAL BACTERIA INFILTRATION THROUGH SOIL

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INTRODUCTION

Bacterial pathogens can degrade ground water quality by infiltrating and eroding from land treated with poultry wastes. The potential for ground water contamination (as well as associated health risks and cost of water treatment) greatly depends on the depth of soil to the water table or bedrock and soil structure. Pathogens must move through the soil profile to contaminate ground water (although sinkholes can provide a direct channel from the soil surface to the water table in karst areas). Deep soils have less potential for contamination than shallow soils. Structureless soils retain fecal bacteria better than well structured soils. Research at UK indicates that surface-applied fecal bacteria, and other contaminants, travel rapidly toward ground water through soil pores in well structured, intact soil. Tillage disrupts pores and channels in the tilled layer, and increases water and bacteria contact with soil. To improve our understanding of bacterial movement, and of the potential for ground water contamination, we decided to examine whether tillage affected fecal coliform transport through intact soil amended with poultry wastes. We used poultry wastes because their disposal is an increasingly important waste management issue in western Kentucky.

METHODS

We evenly distributed undercage poultry manure from layer production houses over the surface of intact soil blocks (13 inches per side) to approximate a 5 ton/acre field application rate (about 0.2 lb. of wet manure/block). The soil blocks came from a Maury silt loam in Lexington and were either sod-covered or removed from a field that was chisel plowed to a depth of 5 inches and disked (the soil was too dry for deeper tillage). The total fecal coliforms added to the top of each block ranged from 100 million to almost 5 billion. We looked for fecal coliforms because they are indicator bacteria used for water quality standards in Kentucky. A laboratory rainfall applicator simulated rain at

0.4 inch/hour for 36 hours, during which we sampled the leachate below the soil blocks every 4 hours.

RESULTS

Most of the poultry waste added to soil is broiler litter which is drier, less compact, and has 100 to 1000 times fewer fecal coliforms by weight than laying house manure. However, fecal coliforms should behave the same once leaching begins, regardless of whether they come from litter or manure. Our results should be applicable to litter as well as manure application to soil.

Ten percent of the area beneath the soil blocks accounted for between 63 and 100 % of the total drainage. This means that preferential flow through intact soil pores let water bypass much of the soil mass that would otherwise filter pathogens and chemicals. Water movement and fecal coliform transport were significantly correlated. Even though we applied fecal coliforms uniformly to the top of the soil blocks, they leached from just a few areas at the bottom. On average, 10% of the area beneath the soil blocks accounted for 94% of the total fecal coliforms that leached (the range was from 77 to 100 %).

Figure 1 shows the fecal coliform leaching patterns for representative sod-covered and tilled soil blocks. There were 18 million fecal coliforms/100 ml in the drainage we collected from the sod-covered block after 4 hours (Figure 1). The standard for fecal coliforms in primary contact water (bathing and swimming water) is only 200 CFU/100 ml. Fecal coliform concentrations in the three tilled blocks were similarly above water quality standards in the first drainage we collected.

The fecal coliforms leached from the waste in a pulse; the more numerous the fecal coliforms applied, the higher the maximum concentration in the pulse. Figure 1 shows that the maximum fecal coliform concentrations appeared after about 3.1 acre-inches of rain fell on the sod-covered soil block. In the tilled soil block, fecal coliforms were held up in the soil profile, and the maximum concentration of fecal coliforms in drainage didn't appear until 6.2 acre-inches of rain fell. The delay was probably because tillage disrupted preferential flow paths in the upper 5 inches of soil. On average, maximum fecal coliform leaching occurred after about 2.4 acre-inches of rain fell on sod-covered soil blocks and not until about 6 acre-inches of rain fell on tilled soil blocks. Although tillage did not hinder the flow of fecal coliforms sufficiently to meet water quality standards for primary contact water, our results are encouraging and suggest that more extensive tillage does retard their movement.

Rainfall delivering 1.6 acre-inches of water (the amount of rain applied in 4 hours) was sufficient to drive bacteria-contaminated water to a depth of at least 13 inches in the Maury soil, and presumably to as great a depth in similarly well drained, well structured soils. The potential exists for leaching to greater depths with the same rainfall because of preferential flow, but we can't extrapolate with confidence beyond the depths we sampled. Between 1990 and 1995, rain exceeded 1.6 acre-inches 52 times (13 % of all measurable rains) at the Lexington site from which we removed the soil blocks. We previously showed that fecal bacteria applied to a Maury soil can move at least 35 inches deep when less than 1.6 acre-inches of rain falls after application (Soil Science News and Views, Vol. 17, No. 4), so the potential for preferential flow to contaminate ground water with fecal bacteria at this site appears to be high. However, rain exceeding 3.1 acre-inches occurred only 8 times (2% of all measurable rains).

Tilled soil reduces the potential for leaching the peak concentration of fecal coliforms from poultry manure. For the tilled soil block in which fecal coliforms most rapidly leached, the maximum fecal coliform populations appeared after 4.6 acre-inches of water fell. That much rain only occurred twice in Lexington between 1990 and 1995. So, the potential for maximal fecal bacteria concentrations to leach through a tilled Maury soil in a single rain is probably negligible.

CONCLUSIONS

Tillage made it unlikely that the maximum leachable fecal coliform concentrations in surface-applied poultry manure would contaminate ground water during a single rain. Nevertheless, fecal coliforms moved rapidly through soil in preferential water flow regardless of whether the soil was tilled or sod-covered. Their concentration in drainage water was thousands of times greater than water quality limits. This is a problem in well structured, shallow soils, if preferential flow reaches ground water, and inadequate dilution or treatment of ground water occurs before its use.

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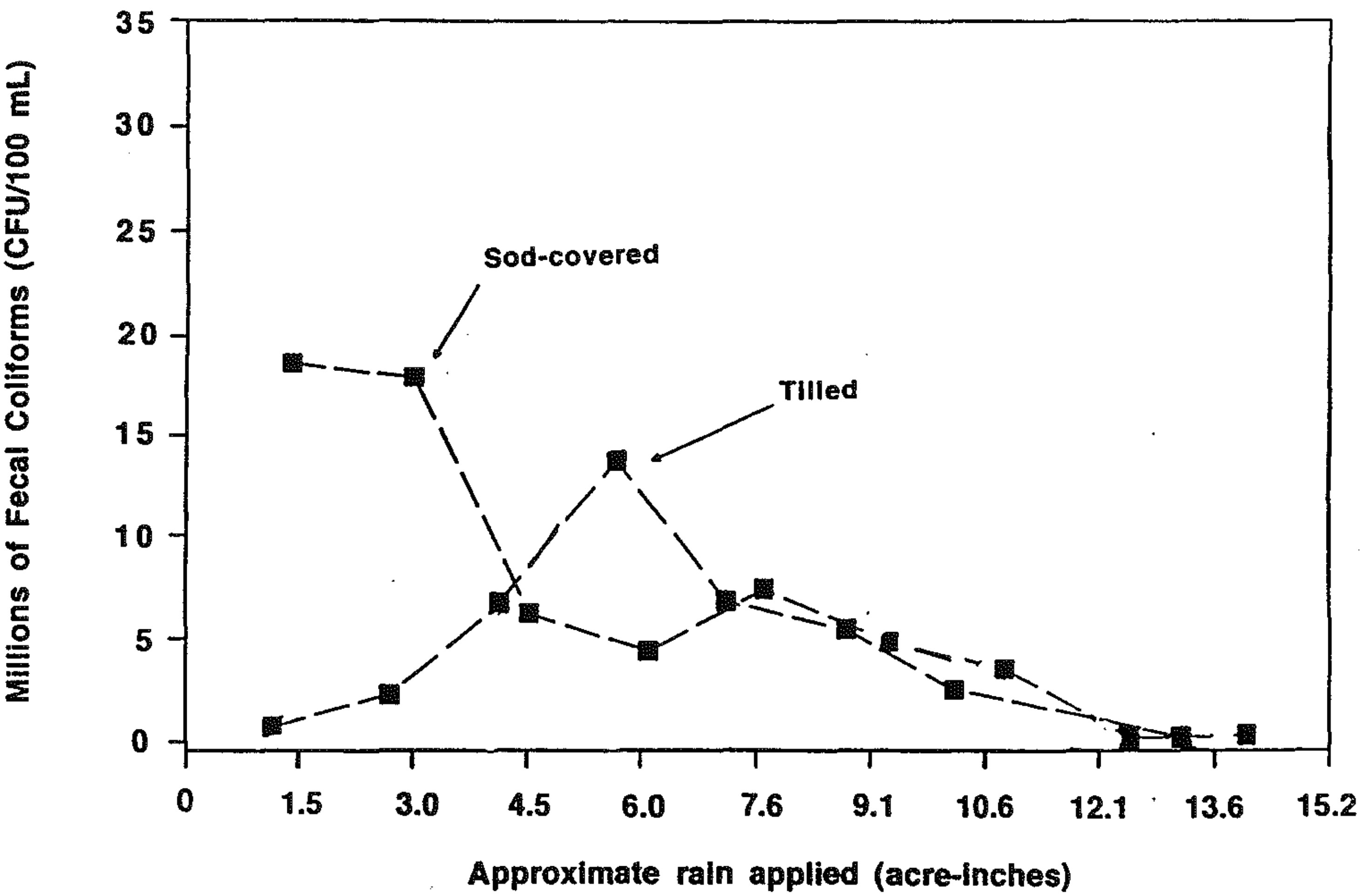
FIGURE LEGENDS

Figure 1. Fecal coliform leaching patterns for representative sod-covered and tilled soil blocks.



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