MITIGATING FARMING SYSTEMS IMPACTS ON THE LANDSCAPE

By: Dr. Tim Harrigan

Manure properly managed is a valuable soil amendment and source of crop nutrients, but poorly managed manure is a potential pollutant. Farmers throughout the Great Lakes Region are becoming increasingly aware of a serious threat to the waters of the State: preferential flow of liquid manure to subsurface drains through macropores. Macropores are large, continuous openings in the soil formed by plant roots, soil fauna, cracks, fissures and other natural phenomena. Nutrients and contaminants that escape from the application site by preferential flow or in runoff are not recycled in the cropping system. These pollutants contribute to the eutrophication of surface waters, and water-borne fecal pathogens are an immediate health threat. Tillage has been suggested as a way to disrupt macropore structure and inhibit preferential flow, but excessive tillage can bury protective crop residues and increase sediment and contaminant loss from wind and water erosion. There is a need for manure management guidelines that capture land applied manure in the root zone for nutrient recycling and pathogen deactivation.

A rolling-tine harrow fractures the soil and improves infiltration with little soil inversion or loss of protective residue.

Fecal coliforms are enteric bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Because *E. coli* bacteria have little ability to multiply in the natural environment, or to survive for long periods outside a warm-blooded host, *E. coli* is often used as an indicator organism to gauge the potential pollution of surface and ground waters from animal sources. Soil can be an efficient media for remediation of bacteria and pathogens if the application rate does not exceed the assimilative capacity of the soil. In general, fecal pathogen survival is limited by high or low pH, sunlight, drying, freezing and thawing, high temperatures, and exposure to oxygen. Because tillage tends to warm, dry and aerate the soil, and crop residue cover insulates the soil and conserves soil moisture, tillage and cropping systems have an impact on the fate of fecal pathogens in the soil.

Portable rainfall simulators were used to simulate rainfall events on days 3, 10 and 21 after manure application.

During the past year I have been working with Dr. Bill Northcott, former graduate student Anne Thomas, and B.E. undergraduate students Paula Steiner, Pete Wyckoff and Paul Forton to evaluate the effectiveness of aeration tillage in mitigating manure contaminant losses from farm land. In aeration tillage a rolling-tine harrow is used to loosen and fracture the soil thereby improving infiltration and reducing runoff with little soil inversion or loss of protective crop residues. Such a system may provide an opportunity to better integrate no-till cropping and livestock systems by stabilizing land applied manure and improving the efficiency of nutrient cycling. The objective of the work was to evaluate the effect of a rolling-tine aerator and manure slurry application system in preventing overland flow and runoff of soil and bacterial contaminants applied to grassland and untilled wheat stubble in the natural environment. The work was funded by *The Great Lakes Basin Program for Soil Erosion and Sediment Control.* The basin program is coordinated by the *Great Lakes Commission* in partnership with the *US Department of Agriculture (National Resources Conservation Service), US Environmental Protection Agency* and the *US Army Corps of Engineers*.

Two runoff trials were conducted in July and August 2003 on the University Farms at Michigan State University. A dairy manure slurry was applied to: 1) an untilled wheat stubble, and 2) a mixed-grass pasture on a gently sloping (6-8% slope) Capac sandy loam soil. Aeration tillage was provided by a rolling-tine harrow drawn behind a 3,600 gal slurry manure tanker. The rolling-tine harrow was coupled with a AerWay SSD® (sub-surface deposition) slurry distribution system. The application rate was 4,500 gal/acre on the mixed-grass pasture and 6,000 gal/acre on the wheat stubble. A portable rainfall simulator was used to simulate a continuous flow rainfall event with an intensity of 2.75 in. h^{-1} to generate runoff. The rainfall events were conducted at each site 3-days, 10-days and 21-days after manure application. Runoff samples were collected to evaluate runoff volume, sediment, COD, *E. coli* and mineral constituent concentrations in the runoff. There were considerable differences among the sites.

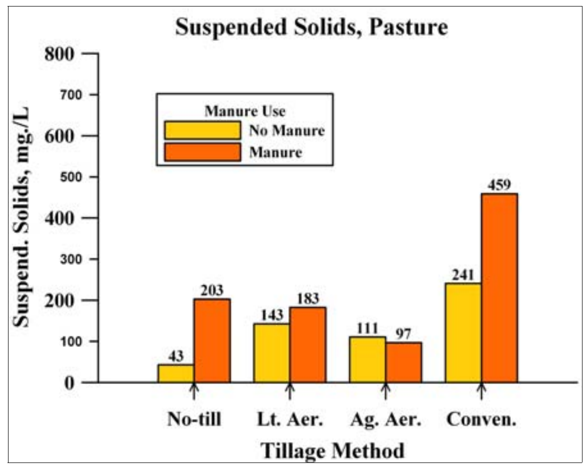

Fig. 1- Suspended solids in the runoff generally increased as tillage intensity increased and when manure was applied.

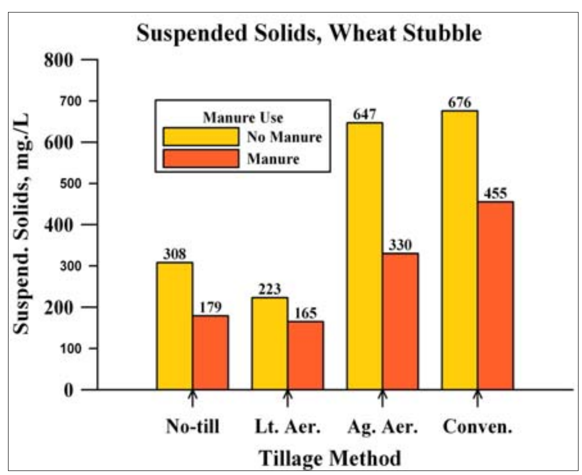

Fig. 2 - The manure slurry contained sawdust bedding that formed a surface crust and reduced suspended solids in the runoff.

Even small amounts of crop residue on the soil surface help to prevent runoff. Crop residue on manured land can slow the die-off rate of fecal pathogens by blocking ultraviolet (UV) radiation and insulating the soil surface to provide a cool and moist environment. The aeration tillage caused little reduction in vegetation or crop residue cover. Vegetation and crop residues covered 98% of the surface after aeration tillage of the pasture while the wheat residue cover was reduced from about 40% to 30%. Residues covered only 5% of the surface of the conventionally tilled ground.

The greatest concentration (mg/L) of suspended solids from the non-manured wheat stubble was from the most intensively tilled plots (Fig.1). There was little difference between the most aggressive aeration (647 mg/L) and conventional tillage (676 mg/L). There was a 28% reduction in runoff from the lightly aerated plots (223 mg/L) compared to no-till (308 mg/L) plots, presumably from an increase in surface roughness and infiltration with little loss of crop residue. When the dairy slurry was applied to the wheat stubble the concentration of suspended solids in the runoff decreased by an average of 38% across tillage methods. The mixture of sawdust and organic solids in the manure formed a protective crust that covered about 80% of the surface of the no-till plots and 40% of the aerated plots. Such a crust appears to have reduced soil borne particulate in the runoff, presumably by reducing particle detachment from rain drop impact.

The concentration of suspended solids in the runoff collected at the pasture site was generally higher following manure application (Fig. 2). Although we have not yet fully characterized the nature of the collected solids, there was likely less sediment carried in the runoff from the pasture than from the wheat ground which was tilled more intensively and had less residue cover. The increase in total solids from the manured no-till pasture was probably largely organic solids and dissolved mineral constituents related to the manure application. There was little difference in runoff between the no-till and aerated plots at the pasture site.

Although the pasture site had not been grazed for a few years and no manure had been applied to the wheat ground for at least 10 months, there was a variable but low level of *E. coli* in the runoff from the non-manured plots, likely from wildlife contact. Generally, *E. coli* concentration in the runoff decreased with time and decreased as tillage intensity increased. We will report on the results of the sediment and bacterial concentrations in the runoff at the *International Meeting of the ASAE* in Ottawa, Canada in August. Additional work is planned to develop meaningful guidelines for capturing land applied manure in the root zone for efficient nutrient cycling and pathogen treatment to preserve the quality of the environment.