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Interaction of Rotavirus and Cryptosporidium parvum Oocysts with Soil Particles and Vegetative Filter Strips

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Abstract:

Vegetative Filter Strips (VFS) have long been used to control the movement of agricultural nutrients and prevent them from reaching receiving waters. Our previous studies have shown VFS also dramatically reduce both the kinetics and extent of Cryptosporidium parvum (C. parvum) oocysts overland transport (Trask JR, et al, J. Environ. Qual. 2004:33:984-993). In this study, we have developed, calibrated and used a small-scale, laboratory rainfall simulator, along with dynamic pathogen-soil microbial adhesion incubations, to investigate possible mechanisms responsible for the ability of VFS to reduce both C parvum oocyst and rotavirus overland transport. Measurement of the survival kinetics of infectious rotavirus, when incubated with soil, water, and individual soil particles (sand, silt, and clay) at various temperatures, indicate that while soil is marginally thermal protective, particularly at higher temperatures as compared to water, clay and especially sand particles markedly reduce rotavirus survival or extractability. Measurement of the kinetics of C. parvum adhesion to individual sand, silt, and clay soil particles revealed that oocysts associate over time, albeit relatively slowly, with clay but not silt or sand particles. Measurement of oocyst overland transport kinetics, soil infiltration depth, distance of travel, and adhesion to vegetation indicate that oocysts move more slowly and penetrate the soil profile to a greater extent on a vegetated surface than on a bare soil surface. Only a very small fraction of the oocysts become attached to vegetation at the soil-vegetation interface on VFS. These results suggest VFS function to reduce pathogen overland transport by primarily decreasing surface flow enough to allow pathogen penetration within the soil profile followed by subsequent adhesion to or entrapment within clay particle aggregates (oocysts and rotavirus), sand particles (rotavirus), or inactivation by sand particles (rotavirus).

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Impact Statement:

The above output activities have resulted in the following new knowledge. 1. The parameters for design and manufacture of a laboratory-scale, rainfall simulator that can be calibrated to yield field-relevant overland transport data. 2. Our experiments on the effects of soil on survival of rotavirus infectivity suggest that soil is thermal protective, especially at temperatures approaching 37 C. The infectivity of rotavirus held in aqueous suspension at 37 C decays to almost zero in 8-10 days and follows first-order kinetics. In contrast, the inactivation of rotavirus infectivity in hydrated soil is delayed for nearly 3 days before appreciable loss in virus infectivity is seen. Approximately, 50% of the input virus infectivity can be recovered from intact soil following at least 18 days incubation at 25 C as compared to only 20% infectivity remaining when the virus is held in aqueous solution. Interestingly, these effects are true only for intact soil, since incubation of rotavirus in equivalent amounts of pure sand and clay particles accelerates the decay of infectivity at all temperatures studied. In particular, sand appears to have a pronounced ability to either inactivate rotavirus or bind it in a manner that inhibits its recovery following water extraction. It will be interesting, therefore, to test soils with varying sand content during future rotavirus overland transport experiments. 3. In contrast, to rotavirus, Cryptosporidium appears to survive well under all environmental conditions tested thus far. Infectivity begins to decline following 2 months of collection or deposition from the cow. While we are currently in the process of examining the kinetics of survival of oocyst infectivity under different conditions of soil and soil particle exposure, our newest data suggest oocysts have an particular affinity for clay particles. Exposure of oocysts to clay at 25 C results in marked aggregation of the clay and oocysts which does not occur with either silt and sand particles. The affect this clay-specific aggregation has on survival of infectivity, water extractability, and overland transport across bare and vegetated filter strips is currently being determined.

Publications: (4)

P. C. Davidson, P. K. Kalita, M. S. Kuhlenschmidt, T. B. Kuhlenschmidt, and S. J. McLaughlin (2007) Survival and Fate of Cryptosporidium parvum and Rotavirus in Soil-water Environment, Annual Conference of the American Society of Agricultural and Biological Engineers, Minneapolis, MN.

M. S. Kuhlenschmidt, T. B. Kuhlenschmidt, P. C. Davidson, and P. K. Kalita (2007) Control of Cryptosporidium and Rotavirus Contamination in Agricultural Watersheds, USDA-CSREES National Water Conference, Savannah, GA.,

S. J. McLaughlin, T. B. Kuhlenschmidt, P. K. Kalita and M. S. Kuhlenschmidt (2008) Microbial Adhesion of Cryptosporidium parvum Oocysts: Interaction with Soil and Vegetated Filter Strips (submitted: Applied and Environmental Microbiology)

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