Report as of FY2006 for 2006KY69B: "Pervious Concrete for Solid/Liquid Separation and Waste Remediation"

Publications

- Dissertations:
  - Luck, Joe, 2007, Effects of Pervious Concrete on Potential Environmental Impacts from Animal Production Facilities, MS Thesis, Department of Biosystems and Agricultural Engineering, University of Kentucky, Lexington, Kentucky, 61 p.
- Conference Proceedings:
  - Workman, Stephen R. and Joe David Luck, 2007, Effects of Pervious Concrete on Potential Environmental Impacts from Animal Production Facilities, in Proceedings of the Kentucky Water Resources Annual Symposium, Kentucky Water Resources Research Institute, Lexington, Kentucky, p 75-76.

Report Follows

Problem and Research Objectives

An increasing problem associated with animal production is the runoff of manure, nutrients, and pathogens into surface and ground water resources. Confinement barns, handling facilities, manure storages, and composting sites are designed to concentrate the animals which, in turn, can concentrate the waste generated by these animals. These systems are effective for animal production, but are far from perfect at controlling or reducing runoff laden with excess nutrients and pathogens. The majority of nutrients in the runoff from these facilities are associated with solids in the wastewater. Means to control or limit solids from leaving an area will affect the ultimate quality of water in the region.

Pervious concrete is a mixture of coarsely graded aggregate and cement that results in a material that easily transmits water. Pervious concrete has mainly been used to control runoff from parking lots and to allow groundwater recharge. Research conducted in recent years has shown that there may be some water quality benefits from using pervious concrete in urban areas. Since the concrete mixture has a porosity and permeability, there could be several advantages of using pervious concrete for agricultural purposes including solid/liquid separation and waste remediation. We utilized laboratory testing to demonstrate how the properties of pervious concrete could provide new methods for conserving natural resources.

Methodology

Few tests have been conducted on pervious concrete to determine the hydrologic characteristics of different concrete mixtures and their capability to separate solids from liquids. Consequently, laboratory tests on the pervious concrete specimens were used to determine the effects of porosity and permeability on solids transport through the concrete matrix.

Additional tests were conducted on replicated samples of pervious concrete made from two aggregate sources (river gravel and limestone) with two size fractions of each aggregate. Compost composed of beef cattle manure and bedding was placed on top of the pervious concrete specimens and one liter of water was filtered through the compost and pervious concrete for two separate daily leaching events. This process was also conducted using a non-reactive No. 80 wire mesh screen. The effluent from both filtration methods were collected and analyzed for BOD, EC, DOC, ammonium, nitrate, nitrite, total nitrogen, soluble phosphorus, and total phosphorus. The results were compared to determine the solid/liquid separation characteristics of pervious concrete versus the wire screen.

Weekly rainfall simulations were conducted after manure was applied to the surface of pervious concrete specimens. The effluent from the manure and pervious concrete was tested for five-day BOD, dissolved organic carbon, ammonium, nitrate, nitrite, total nitrogen, soluble phosphorus, total phosphorus, and fecal coliform. The

results were analyzed to determine the effects of multiple rainfall events on nutrient and analyte concentrations from the animal manure and pervious concrete. The effects of the pervious concrete on fecal coliform populations in the effluent were also observed. Between rainfall events, gaseous carbon dioxide and ammonia concentrations were measured to determine if microbial activity and decomposition were occurring in the animal waste applied to the surface.

Principal Findings and Significance

Laboratory tests were able to demonstrate that different aggregate types used in the pervious concrete mixtures have an effect on the amount of material retention within the pervious concrete specimens. T- tests indicated that the mass of compost retained on the surface was significantly greater when smaller aggregate sizes (#8 river gravel) were used ($p = 0.012$). Nutrient analyses were conducted on the effluent from the compost and pervious concrete and compared to values from an identical test performed by filtering water through compost on a No. 80 wire mesh screen. These tests indicated that filtering the compost effluent through pervious concrete resulted in significant reductions in total nitrogen, soluble phosphorus, and total phosphorus compared to the wire screen. There were no consistent significant differences between the effects of filtering with pervious concrete or wire mesh screen with respect to other analytes (e.g. dissolved organic carbon, ammonium, nitrate, and nitrite). Effluent BOD levels from the compost and pervious concrete for both daily leaching events (38.7 and 42.5 mg/l, respectively) averaged above typical allowable wastewater concentrations of 30 mg/l. Use of the pervious concrete for filtering resulted in significantly higher (p value <0.0001) pH (9.3) compared to the effluent pH from the wire mesh screen (7.7).

Statistical analysis indicated that significant increases and decreases can occur in analyte concentrations as a result of multiple rainfall events. The highest concentrations of some analytes (five-day BOD, nitrate, total nitrogen and total phosphorus) in the effluent occurred after the first rainfall simulation. Maximum concentrations for other analytes (DOC, ammonium, nitrate, and soluble phosphorus) occurred after subsequent rainfall events. Further analysis of the effluent indicated a significant decrease in fecal coliform concentration one week after the initial rainfall simulation. Ammonia and carbon dioxide emissions from the manure and pervious concrete specimens were also monitored for a five day period following three weekly rainfall events. Results indicated that the pervious concrete was capable of providing an environment where ammonia and carbon dioxide could be volatilized. The carbon dioxide emissions indicate microbial activity where immobilization of nutrients and decomposition of the manure could occur. Therefore, additional nutrients could be retained by microorganisms in animal waste deposited on the pervious concrete surface.