VEGETATIVE FILTERS FOR IMPROVING ENVIRONMENTAL QUALITY

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Summary

Nonpoint source pollution from agricultural areas has been recognized as a major contributor of surface and groundwater quality problems. Sediments, pesticide and nutrient runoffs, and microbial pathogens from farmlands may severely affect quality of water resources. A majority of Kansas river basins contains high concentrations of fecal coliforms, nitrogen, phosphorus, and sediments. The use of vegetative filters strips (VFS) has been identified as one of the best management practices to reduce pollutant concentrations in surface water sources. Vegetation planted between pollutant sources and receiving water accomplishes this by filtration, deposition, infiltration, adsorption, volatilization, plant uptake, and decomposition processes. The effectiveness of VFS in reducing nonpoint source pollution is being evaluated at four Kansas watersheds. Water samples are being collected at inlets and outlets of the VFS and analyzed for nutrients, sediments, and fecal coliform concentrations. Total nitrogen and phosphorus concentrations were reduced 26 and 14%, respectively, in one watershed and by 73 and 71%, respectively, in another. On a mass basis, total nitrogen and phosphorus reductions were 51 and 42%, respectively, in one and 60 and 52%, respectively, in the other. In the third watershed, mass flow rate of fecal coliform was reduced significantly by the VFS. If maintained properly, VFS can be used to improve water quality in agricultural areas.

(Key Words: Environment, Feedlot, Nutrients, Vegetation.)

Introduction

Health-related problems and other environmental degradation associated with water quality have been major concerns for decades. Nonpoint source pollution from agricultural production sites has been recognized as a major contributor to surface and groundwater quality problems. Sediments, pesticide and nutrient runoffs, and microbial pathogens from farmlands and feedlots may severely affect quality of water resources. A majority of 12 major river basins in Kansas contain high concentrations of fecal coliform, nitrogen, phosphorus, and sediments. High nitrate-N concentrations in surface and groundwater in agricultural areas have been documented. Several lakes and streams are in the process of eutrophication because of high annual loading with nitrogen and phosphorus from runoffs from agricultural areas. Sources of coliforms include runoff from animal feedlots, livestock grazing lands, wildlife, and other waste handling systems.

Among other technological advances, vegetation has been identified as a natural filter for several pollutants. Vegetative filter strips (VFS) are bands of planted or indigenous vegetation that can be situated between pollutant sources and receiving water to filter pollutants out of drinking water sources. A VFS can remove sediment and other pollutants contained in runoff or wastewater by filtration, deposition, infiltration, absorption, volatilization, plant uptake, and decomposition.

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Experimental Procedures

Effectiveness of VFS in reducing sediments, nutrients, and fecal coliform bacteria in Kansas is being investigated at four different watersheds. These studies started in 1996 and will continue for several years for long-term evaluation. These watersheds have received wide attention because of *C. parvum*, *E. coli*, and other non-point source pollutants (mainly N, P, and sediments) in drinking water sources, and VFS have been installed at those sites.

Cheney Reservoir. This watershed is located in south central Kansas (North Fork Ninnescah watershed, Reno County) near Wichita. The soil is Shellabarger fine sandy loam, and the average annual rainfall is about 30-35 in. Cheney Reservoir is essential to the inhabitants of south-central Kansas as a public water source, wildlife area, and recreational site. The City of Wichita draws 40 to 60% of its water supply from this reservoir. About 600 acres of the Cheney Reservoir's watershed are animal confinement areas. Runoff from these feedlots with high concentrations of nutrients, sediments, and microorganisms has been identified as a major pollution source of the reservoir water.

Herington Reservoir. This watershed is located in central Kansas (Dickinson County) near Herington. Soil in this area is Crete silty clay loam, and the average annual rainfall is 25-30 in. This reservoir supplies drinking water for Herington. Several pastures and cattle feedlots of 30 to 1,000 head occur within its watershed. The major pollutant entering the reservoir has been identified as livestock waste runoff that contains nutrients, sediment, and microorganisms.

Hillsdale Lake. This watershed is located in eastern Kansas (Miami County) near Kansas City. The soil is clay loam, and the average annual rainfall is about 40 in., so this area has the highest runoff potential in the state of Kansas. This recreational lake has been used as a drinking water source. Agricultural nonpoint source pollution and nutrient contribution from several pastures and feedlots in the watershed have been the major water quality problems in this area. In addition to these three sites, another site at Gypsum (near Salina), Kansas was selected recently.

Establishment of VFS. At the Cheney Reservoir site, a VFS was installed in the summer of 1996. A 300-head cattle feedlot discharges into a settling basin just above the strip. Overflow from the basin passes through the filter strip before discharging into a stream that contributes runoff to Cheney Reservoir. Total length of the strip is 775 ft, which is divided into three segments: the upper 440 ft is 50 ft wide on a 1.0% slope, the middle 245 ft is 30 ft wide on a 0.3% slope, and the lower 90 ft is 20 ft wide on a 4.0 % slope. Brome was seeded during the summer of 1996 and was fully established by the end of summer 1997.

At the Herington Reservoir site, several VFS were installed during 1993-1994. Most of the filter strips are well maintained and are in very good condition. One of those strips were selected for use in this study. The filter strip is 1,200 ft long and 96 ft wide and was installed below a 300-head cattle feedlot. The strip has two distinct slopes; 0.5% for the first 500 ft length, and 1.2% for the rest. Brome grass was seeded and fully established in 1995. Among all the filter strips, this one has the highest percent of land covered by vegetation. The vegetation grows up to several feet in height but is harvested two to three times a year.

Three parallel VFS have been established side by side in the Hillsdale Lake site. These strips are 650 ft long and 50 ft wide, below a holding basin receiving runoff from a 300- head cattle feedlot. This strip has a uniform slope of about 2%. Fescue grass was seeded in the summer of 1995 and was fully established by the end of summer 1996.

Runoff Samples. For collecting runoff water samples, automatic ISCO samplers have been installed at the entrance and exit of the VFS at all four watershed sites. Those samplers are programmed to automatically turn on when a runoff event occurs, and to collect runoff samples at predetermined time intervals during the event. Automatic flow measurement systems have been installed to measure runoff rates and volumes for all events. Rainfall amount and intensity at all these areas have been recorded with tipping bucket rain gauges.

Water samples were removed from sites within 48 hours of a runoff event, packed in ice coolers, and transported to Kansas State University. At the laboratory, they were analyzed for total N, NH_4-N, NO_3-N, total P, Ortho P, total dissolved solids (TDS), and total suspended solids (TSS). For *E. coli* assays, water samples were filtered onto membranes and plated on mFC agar. Plates were incubated at 112EF for 24 hr. Filters then were transferred to MUG-EC medium, incubated for an additional 24 hr at 98.6°F and examined with a hand-held UV light. Fluorescing colonies were counted as *E. coli*.

Vegetation samples were taken during the 1997 season for moisture content and chemical analysis, including total N and total P.

Results and Discussion

Results from three sites have partly been analyzed. Water samples from Cheney and Herington watersheds have been analyzed for nutrient and sediment concentrations and the samples from Hillsdale watershed have been analyzed for fecal coliform concentrations. The results from all the three sites indicate that vegetative filter strips can significantly reduce nutrient, sediment, and coliform levels in runoff from small feedlots. In addition, the soil sample data from the filter strips indicate little nutrient accumulation if plant nutrient uptake is high.

Statistical analysis of the Cheney watershed data revealed significant differences between the inlet and outlet masses for total N, total P, NH_4-N, NO_3-N, Ortho P, and total suspended solids ($P<.05$), as well as total dissolved solids ($P<.10$). On an average over five storms at this site without cattle present, the VFS reduced total N, NH_4-N, NO_3-N, total P, Ortho P, and TSS by approximately 26, 44, 2, 14, 18, and 65%, respectively, on a concentration basis. The reductions on a mass basis were 50, 63, 34, 42, 45, and 76%, respectively. Soil total nitrogen did not vary statistically between the three different time periods. However, a general decreasing trend occurred over time, especially in the top 3 ft of the soil profile. Plant total N concentrations did not vary throughout the filter, whereas total P concentrations varied with distance from the filter inlet. On a mass basis, total P and total N both varied with distance from the inlet ($P<.10$).

Statistical analysis of data from the Herington site revealed significant differences between the inlet and outlet masses for total N, total P, NH_4-N, NO_3-N, Ortho P, and TSS ($P<.05$) as well as TDS ($P<.10$). On an average over four runoff events in the Herington watershed without cattle present, the VFS reduced concentrations of total N, NH_4-N, NO_3-N, total P, Ortho P, and TSS by approximately 73, 74, 95, 71, 64, and 78%, respectively. The reductions were 59, 74, 87, 52, 44, and 83%, respectively, on a mass basis. Plant total N concentrations varied with distance from the filter inlet, but total P concentrations did not. On a mass basis, both N and P varied significantly with distance from the filter inlet.

During a runoff event in May, 1998, the bacterial concentrations were higher at the beginning of the event. The concentrations of fecal coliform were reduced significantly by the VFS. Similar trends were observed at the same site in June. Although the concentrations did not seem to decrease at the outlet of the VFS, the total mass of coliform bacteria significantly decreased. This clearly demonstrates that the VFS increases the infiltration rate and reduces the runoff rate and volume.

Results of this study clearly support the findings of other researchers that VFS effectively reduce nutrient, sediment, and bacteria from agricultural areas. The efficiency of vegetation in reducing the pollutant concentration and mass depends on vegetation type, filter strip design, and watershed conditions. Nutrient uptake by vegetation was much higher at the Herington watershed site than at the Cheney Watershed (North Fork Ninnescah) site, most likely because of the difference in the quality of vegetation. At the Herington site, vegetation was established several years ago and excellent growth was observed. At the Cheney site, vegetation was established in 1996 and only a fair cover was established. At the Hillsdale watershed site, the vegetation also was fully established and a high percent reduction in coliform was observed. Regardless of the vegetation differences, good management is required to maintain the VFS. If properly managed, VFS can be used to improve environmental quality in agricultural areas.