Soil Infiltration and Wetland Treatment of Feedlot Runoff

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Summary

Treating feedlot runoff using a soil infiltration area followed by a small constructed wetland can significantly reduce contaminants in the runoff. An infiltration/wetland treatment system has been monitored for three years at ISU's Beef Nutrition Farm near Ames. Overall contaminant concentrations in the wetland effluent are typically 20% or less than the initial runoff concentrations.

Situation

Iowa has over 13,000 farms with open-lot livestock feeding. Only about 300 feedlots are large enough to require a National Pollutant Discharge Elimination System (NPDES) permit, yet the Iowa Department of Natural Resources (DNR) estimates only 10% of these currently have permits. Increased enforcement activities by both the Environmental Protection Agency (EPA) and the Iowa Department of Natural Resources (IDNR) have encouraged large producers (over 1,000 animal units, 1 animal unit (AU) equals a 1000 lb. beef animal) to consider constructing total containment systems. Smaller producers are also looking for ways to improve the quality of the runoff from their feedlots before it reaches surface waters of the state. Operators of beef feedlots of 1,000 head or more must settle solids, and then capture and contain all runoff from their lots. The liquid and solids can then be spread (pumped or hauled) onto agricultural land so that no discharge occurs. Operators of smaller lots, however, can release the runoff after settling solids if the liquid doesn't go directly into surface water bodies.

Alternative technologies offer the possibility of additional runoff treatment in addition to settling solids, without capturing the runoff so that it has to be pumped. Technologies that treat runoff without requiring high management inputs are very attractive for producers, and offer the potential to provide environmental benefits by releasing a cleaner effluent to the lakes, rivers, and streams. In addition they may be cheaper to install than total containment basins that require soil sampling for permeability, and an engineers design and approval. Basins are also expensive to manage because they require a liquid transfer system (either pumping and irrigation or hauling) to remove the collected runoff periodically. Alternative technologies that are commonly considered include vegetative areas or buffers, and constructed wetlands. An additional potential treatment is a soil infiltration area to be used ahead of a wetland.

Although federal regulations will generally not allow alternative technologies to be used for large feedlots, they potentially can be used for small lots. Reduced cost and management requirements are the main advantages of alternative systems. They must also provide effective "cleaning" of the runoff liquid prior to release.

Infiltration Area and Wetland

System design

An infiltration and wetland system has been in use at the Iowa State Beef Nutrition farm west of Ames, Iowa, for three years. The system collects all the feedlot runoff from the 56' X 756' barn with concrete lots, as well as the 110' X 340' earthen lots. Solids are settled prior to leaving the lots. The runoff from the lots plus some additional drainage area around the lots is carried through an underground pipe to the infiltration area. The 120' X 350' infiltration area is approximately 20% of the total drainage area. The infiltration area is surrounded by a two-feet-high berm to hold the runoff until it can infiltrate the soil. This depth allows containment of a 25-yr, 24-hr storm of approximately 5.2 inches before allowing runoff from the infiltration area. The area is seeded to Reeds Canary Grass and harvested once a year. Care is used to keep cattle and machinery off the infiltration area so as not to reduce the infiltration rate. Three, 4-inch diameter plastic tile lines were installed running lengthwise along the area. They are equally spaced, and installed at a typical field tile depth of 5 feet. The tile lines intercept any filtrate and carry it to the wetland. The wetland is simply a small detention area approximately 90' X 150' that was excavated out of the hillside. After it was excavated and compacted, topsoil was replaced in it to provide nourishment for the cattails that were transplanted from nearby road ditches. The cattails were placed in a 3' X 3' grid. They quickly spread and filled in the entire wetland the first summer. Liquid depth is maintained at approximately 18 inches in the wetland. Figure 1 shows the layout of the lots and treatment system.

Sampling is done at three locations to monitor water quality effects. Raw runoff (after solids settling) is sampled as it enters the infiltration area. Water leaving the infiltration area is sampled as it enters the wetland. And water leaving the wetland is sampled prior to release. Chemical analyses have included total nitrogen, ammonia nitrogen, nitrate nitrogen, total phosphorus, and potassium.

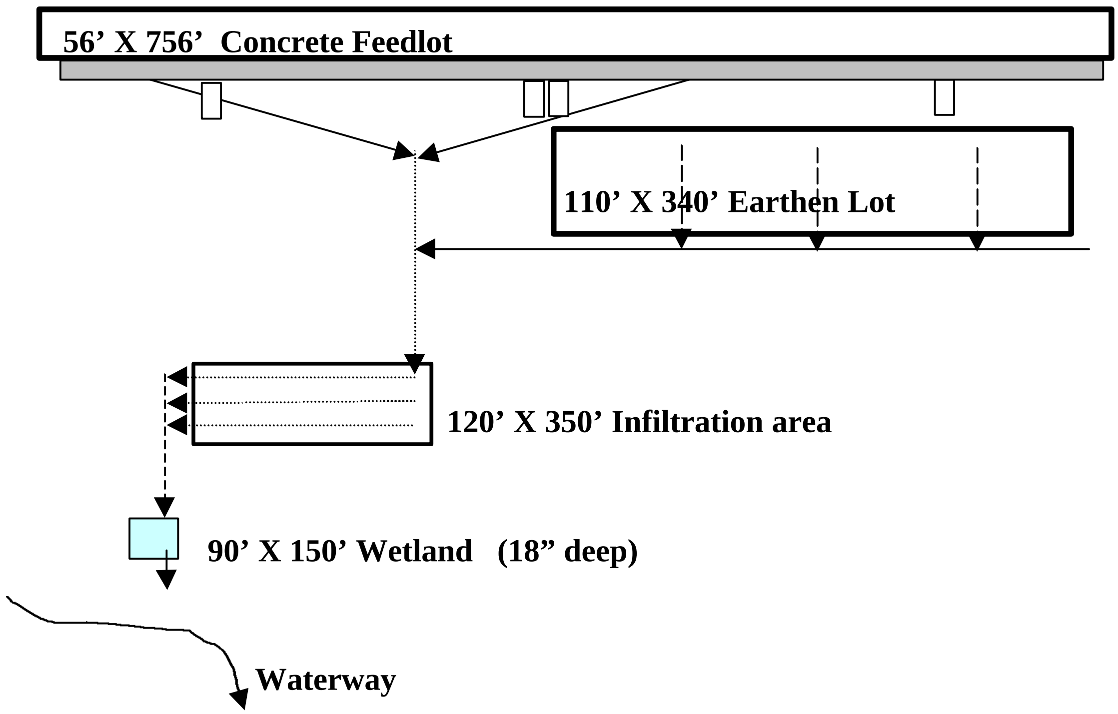

Figure 1. Layout of feedlots, infiltration system, and wetland at ISU Beef Nutrition Farm.

System performance

Overall the infiltration/wetland system has significantly reduced contaminants in the runoff water from the feedlots. The two year average of total nitrogen (N) has averaged 177 mg/l coming from the feedlot settling areas (entering the infiltration area), 31 mg/l leaving the infiltration area (entering the wetland), and 22 mg/l leaving the wetland. The overall reduction in total N concentration was 88% during 1998 and 1999. For ammonia nitrogen, the concentrations were 108 mg/l from the feedlot, and 17 mg/l leaving both the infiltration area and wetland. The wetland did not reduce ammonia. Although ammonia was significantly reduced from raw incoming values, it was still high enough leaving the wetland to be hazardous to some fish. Nitrates in the raw runoff were 0.9 mg/l. They increased to 1.9 mg/l as the liquid moved through the soil and ammonia was converted to nitrate in the aerobic environment. The nitrates were reduced from 1.9 to 1.1 mg/l in the wetland. All nitrate concentrations were well below the 10 mg/l allowed in drinking water. Phosphorus (P) concentrations were also reduced. From a concentration of 34 mg/l exiting the feedlot, it went to 7 mg/l from the infiltration area to 6mg/l leaving the wetland. This level is still well above the concentration that can cause algae growth in water bodies. Figure 2 shows the reductions graphically.

Summary

Open beef feedlot runoff was treated by settling solids, then capturing the runoff in a bermed infiltration area. The tile flow from the infiltration area then passed through a wetland prior to release. Total nitrogen, ammonia, and phosphorus were all reduced significantly from the raw runoff concentrations. Although the N and P concentrations were reduced significantly, they were still above acceptable values desired in lakes and streams. Even though the water was not as clean as we would like, it was significantly better than raw runoff.

Implications

This research shows that runoff quality from open feedlots of less than 1,000 AU can be dramatically improved by using an infiltration/wetland system that requires little management. The cost includes construction of the berm around the infiltration area, tile lines, and wetland construction. A sizable land area is required for the infiltration area, but forage can be harvested from it if care is used not to cause soil compaction. Cost is expected to be less than the cost of a complete detention basin and land application system.

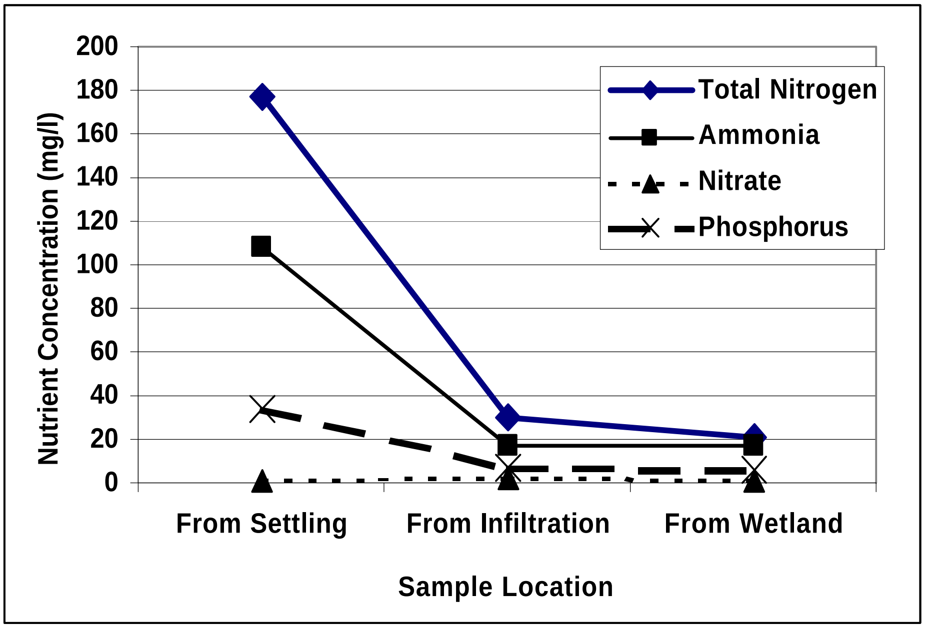

Figure 2. Nutrient concentrations in feedlot runoff as it moves through infiltration/wetland treatment.