Report for 2002NC3B: A Systematic Evaluation of Polyacrylamide for Sediment and Turbidity Control

- Conference Proceedings:
  - Thaxton, Christopher S. and Richard A. McLaughlin, 2004, Optimal hydraulic permeability of composite geotextiles as baffles in a sedimentation basin, Proc. ASAE/CSAE Annual International Meeting, Ottawa, ON, Canada, Paper 218 (SW-224)
  - McLaughlin, Richard A., 2003, Potential improvements in sediment and turbidity controls at construction sites, 2nd Conf. Watershed Mgmt. to Meet Emerging TMDL Environmental Regulations, Albuquerque, NM, Am. Soc. Ag. Eng., Stl Joseph, MI.
- Other Publications:
  - McLaughlin, Richard A., 2005, SoilFacts: Using Baffles to Improve Sediment Basins, NCSU Extension Publication AGW, 429-59.
  - N. Bartholomew, R. A. McLaughlin, and D.L. Hesterberg, 2002. Polyacrylamide to Reduce Turbidity in Runoff. Agronomy Society of America Annual Meetings.
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  - McLaughlin, R. A. and J. W. Gilliam. 2002. Using Natural and Landscaped Buffers to Reduce Pollutant Loading from Agricultural Runoff. Water Res. Research Inst. Of the U. of N. C. Report # 340. 53 pages.
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- Articles in Refereed Scientific Journals:
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- Dissertations:
  - Thaxton, Christopher A., 2004, Investigations of Grain Size Dependent Sediment Transport Phenomena on Multiple Scales, Ph.D. Dessertation, Department of Physics, College of Physical & Mathematical Sciences, North Carolina State University, Raleigh, NC, 194 pages.
  - Bartholomew, Nathanael, 2002, Polyacrylamide for Turbidity Control in Runoff: Effects of Polyacrylamide, Soil, and Solution Properties, MS Dissertation, Department of Soil Science, College of Agriculture & Life Sciences, North Carolina State University, Raleigh, NC, 136 pages.

Title

A Systematic Evaluation of Polyacrylamide for Sediment and Turbidity Control (70196)

Problem and Research Objectives

Properly installed and maintained sediment control devices, such as silt fences and sediment traps, are intended to remove the sand and coarse silt fractions from sediment in runoff. Although they may retain the majority of the sediment carried by runoff, a substantial portion of the silt and clay fractions are not retained and contribute to high turbidity in streams, lakes, and estuaries. None of the devices currently required provide turbidity control. Polyacrylamide (PAM) has been proven to reduce erosion and turbidity under agricultural conditions. Our current laboratory and field tests have shown that PAM can also substantially reduce turbidity in sediment basins and traps, even to or near the current 50 NTU standard. Under the current WRRI grant, we are determining a number of factors involved in maximizing PAM effectiveness: sediment trap modifications, electrolyte interactions, and environmental conditions. These are primarily using the log format to introduce PAM into runoff. However, there are many other methods to introduce PAM into runoff which may be more reliable and effective. Further testing on these is needed to determine the optimal configuration for reducing turbidity.

We will evaluate the effectiveness of a series of sediment and turbidity control systems that can be used as part of a typical sediment trap as well as innovative modifications. The objectives are: 1. Compare the relative effectiveness of modifications to a typical sediment trap to optimize the effectiveness of PAM in reducing turbidity at the outlet. 2. Evaluate combinations of PAM and an electrolyte source for synergistic effects. 3. Evaluate the effects of moisture condition and temperature on PAM release from logs

Methodology

Most of the work will be conducted at the Sediment and Erosion Control Research and Education Facility at the NCSU Lake Wheeler Road Field Laboratory. This site is ideally located as it is convenient to campus for research and it is centrally located for training and demonstrations. We have already installed the infrastructure for testing sediment and erosion control systems under controlled conditions. Some of the work will be conducted under laboratory conditions in the NCSU Soil Science Department. We have three sediment traps with dimensions of 10’ x 20’, 15’ x 30’, and 20’ x 40’. Each has a rock outlet consisting of large stone (Class B) with a 2:1 slope and a 1’ layer of gravel (1/2”– ¾” dia.) on the inside face, which is the “typical” outlet in the North Carolina DENR Land Quality Section Design Manual. The dewatering times are 1-2 hours once the trap is full to the top of the outlet dam (3-4’), or 0.1-0.3 cubic feet per second (cfs). The rock outlets can be closed off and sealed in order to dewater the basin through a skimmer (or other device) attached to 6” PVC pipes buried within the outlet dam. Dewatering times are 10-20 hours for the basins fitted with skimmers. Water for generated storm events is provided from a 10,000 cubic foot pond located 200’ uphill from the testing area. The storage pond is in turn supplied through the farm irrigation system which taps into a large source pond. A 12” pipe brings the water downslope to the testing area by gravity flow, with an overall drop of 8-10’ depending on where the tests are conducted, and flows of up to five cfs are possible. A “T” is located in the pipe at 140’ from the pond with the open end up. Soil is added manually to the water flowing through the pipe at this point. Stockpiles of two different sediment types are presently available for our experiments, including a sandy loam surface soil and a clay subsoil. The soil is first screened through a 1” coarse screen to remove large rocks and debris before it is used for experiments. Water flow in the pipe is regulated manually by a valve between the source pond and the “T” and measured by an Isco Area Velocity flow module attached to an Isco 6700 sampler. The sampler obtains samples at set intervals from the head of the sediment basin near the pipe outlet. The water leaving the basins is channeled into either 1.5 or 2.0’ H-flumes fitted with an Isco bubbler flow meter and sampler. Water sampling occurs at set intervals, usually 5-10 minutes depending on dewatering times, at the head of the flume. The discharged water is then dispersed using a level spreader into relatively flat areas of either pine plantation or grass cover. These areas generally retain the discharge, but there is a three-cell constructed wetland below these areas if the flow exceeds their capacity.

Principal Findings

The results indicate that the PAM logs were usually much less effective when initially dry at the start of the 25 minute simulated storm event. The turbidity was higher with lower water temperatures, most likely due to increased water viscosity as opposed to reduced PAM release from the logs. The optimal basin configuration for maximum turbidity reduction using PAM included porous baffles made of a jute/coir combination. The outlet type did not significantly change the turbidity reduction by PAM. Sediment bags were tested with and without PAM injected as a solution and always had reduced turbidity with PAM. Less porous bag materials had lower turbidity in discharge but also clogged more quickly. For a Piedmont soil, the addition of gypsum generally increased turbidity at low PAM concentrations (< 1 mg L^{-1}) for five PAMs with varying properties. The optimal PAM concentration was usually close to 1 mg L^{-1} and higher doses tended to increase turbidity, but this effect was dampened when gypsum was added. This combination of effects suggests that the gypsum was competing with suspended sediment for binding sites on the PAM molecules. In contrast, several Coastal Plan soils responded to PAM only in the presence of gypsum. There was no soil property which correlated with this gypsum response in all soils, but sand content and extractable Fe were the most highly correlated.

Significance

Although not widely used yet, the approach currently available is primarily using PAM logs to dispense the material into the runoff stream and then use various filtering and settling systems to remove the flocs. This research provides information to expand the current application of PAM to reduce turbidity in construction site runoff. This is expected to add flexibility and reliability to the use of PAM in these applications.