Anionic Polymer for Construction Runoff Treatment

TECHNICAL BRIEF

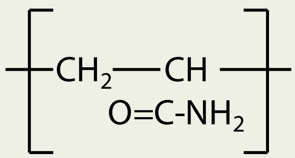
Erosion and Sediment Control Series

Polymers have been used for decades in a variety of industries, and have proven particularly effective in facilitating solid liquid separations during waste and drinking water treatment, and the clarification of various types of effluents. Their effectiveness lies in their ability to enhance coagulation and/or flocculation of fine particles, allowing for more rapid settling in downstream detention practices. Polymers have more recently been applied in onsite treatment of stormwater, particularly for sediment-laden runoff from construction sites.

In this field study, the performance of an anionic polymer (polyacrylamide) was evaluated for construction runoff clarification at a development site in Vaughan, Ontario. The main objectives of the study were to quantify the polymer's performance, determine which application method would be most effective, and identify the key factors that affected performance. Assessing polymer performance under local soil and climate conditions, and testing the effectiveness of different applications, are essential first steps in determining the future role of polymers in improving construction sediment management in southern Ontario.

What are anionic polyacrylamides?

PAMs are a group of high molecular weight, water soluble molecules formed by polymerization of the monomer acrylamide. Anionic (negatively-charged) PAM is produced when acrylamide is polymerized with an aionic co-monomer.



Polyacrylamide (PAM) is one of the most common polymer flocculants on the market. In addition to water clarification, it can be used for erosion control, as it causes soil particles to bind together and form an erosion-resistant surface. Anionic PAM is the most common synthetic polymer used to prevent erosion in irrigation furrows and on construction sites. The polymer was selected for this evaluation based on promising performance and low toxicity findings in studies completed to date.

STUDY SITE

Field monitoring was carried out at a 77 ha construction site in Vaughan, near Major MacKenzie Road and Pine Valley Drive, and draining to a tributary of the East Humber River. Field monitoring focused on evaluation of two applications of anionic PAM to treat stormwater being pumped out of an on-site construction sediment control pond. In the first application, PAM products were used in a roadside ditch, and in the second application the product was used in a mixing tank installed in series with a larger settling tank.

APPROACH

The primary PAM product used was the Floc Log®(Applied Polymer Systems Inc.), a semi-solid block composed of drinking water treatment chemicals and anionic PAM. In the ditch application an anionic PAM-based powder (sold by APS as Silt Stop®) was also used. For each application a polymer-free control was set up in order to quantify the added sediment removal benefit the polymer provided. Samples collected were analyzed by the Ontario Ministry of Environment Laboratory for turbidity, total suspended solids (TSS) concentrations and particle size distribution (PSD).

Ditch application

A portion of the roadside ditch bordering the construction site was converted into a polymer based treatment system for water pumped from an onsite sediment control pond. A 94-metre long stretch was retrofitted with a polyethylene liner, rock check dams, 8 Floc Logs®, and jute netting coated with Silt Stop®. A control for the experiment was installed on a 52 m long stretch which included the same components except for the PAM products.

Figure 1: Polymer ditch.

Two separate experiments were carried out during periods of elevated pond turbidity. In the first experiment, water was pumped into the ditch at 11 L/s and automated samplers set up at the beginning and end of each ditch collected hourly samples for 20 hours after a 60 mm rainfall on Aug. 20, 2009.

During the second experiment on Sept. 9, 2009, influent turbidity was elevated through manual disturbance of pond sediments near the pump intake. Grab samples were taken at different points in the ditches to measure the decline in turbidity along the flow path. Samples were taken at two flow rates (8 L/s and 11 L/s) and at different influent turbidities to assess the extent to which these factors would influence performance.

Tank application

In the second application, the anionic PAM product was introduced through a polymer mixing tank in series with a large settling tank downstream and a sediment bag at the end of the system for final filtration and flow dispersion. The control consisted of the same system but without the polymer mixing tank.

The 1.8 m^3 mixing tank contained three separate compartments: the top to hold the Floc Logs,® and the bottom two to force mixing of the water and the dissolved PAM. Eight large Floc Logs® - equivalent to double the mass of those used in the ditch experiment - were placed in the mixing tank. Water was pumped from the pond to each system at a rate of 12.6 L/s.

Field monitoring of the polymer and control tank systems occurred in Dec. 2009. Samples were collected on two occasions: (i) during a rainfall event on Dec. 2; (ii) during manual disturbance of pond sediments on Dec. 4. For samples from the rainfall event, turbidity levels were found to be too low for the test (< 80 FTU). As a result, samples were not submitted for laboratory analysis, but turbidity was measured using a handheld turbidimeter.

Figure 2: Polymer mixing tank.

FINDINGS

The addition of polymer resulted in better removal of TSS than passive treatment without polymer. Effluent TSS concentrations were evaluated against a target of 25 mg/L, which is a widely accepted threshold for preventing impacts to fish and fish habitat (e.g., Newcombe, 1986). Despite a wide variation in performance among different experiments, the systems in which polymer products were used were consistently more effective at reducing TSS than their corresponding control systems for both applications (Figure 3). The polymer systems yielded the best results during the Sept. 9 and Dec. 4 experiments, with a ditch and tank TSS reduction of 88% and 92%, respectively. Although this indicates that treatment through a polymer mixing tank was slightly more effective than ditch treatment with Floc Logs®, it should be noted that the ditch treatment produced considerably lower TSS effluent concentrations (average of 20 mg/L compared to 42 mg/L).

Poor treatment using polymer during one experiment highlighted the importance of designing treatment systems with optimized dosing, mixing and filtration. The Aug. 20 ditch experiment was the only one for which the average effluent TSS concentration was higher for the polymer system (Figure 3). Reasons for the poor performance of the polymer ditch during that experiment include the less than optimal log orientation and the finer PSD of the polymer ditch influent. The modest reduction in turbidity observed in the polymer and control tanks on Dec. 2 (16.2% and -1.5%, respectively) is also likely attributable to a finer influent PSD, as well as a lower influent turbidity compared to Dec. 4. Influent turbidity (or TSS concentration) influences percent reduction in two ways. First, the way percent reduction is calculated means that, for a fixed effluent concentration, a more turbid influent will result in a greater percent reduction. This has been documented by others (e.g. Wright Water Engineers and Geosyntec Consultants, 2007; Lenhart, 2008). Second, the polymer may be most effective within a certain turbidity range, and the influent turbidity of 55 FTU on Dec. 2 may have been below this optimal range.

Re-positioning of the Floc Logs® in the ditch and the addition of filtration to the mixing tank system substantially improved TSS removal performance. During the ditch experiment, flows were observed to short circuit around the Floc Logs®. Altering the Floc Log orientation to optimize contact times increased the rate of TSS removal from 8% to 88%. While no filtration was provided at the end of the ditches, the effect of filtration in the polymer mixing tank experiment was substantial. Adding a sediment bag to the end of the treatment train in that experiment resulted in TSS effluent concentrations of only 13 mg/L, compared to 42 mg/L without the bag.

TSS concentrations progressively decreased with increasing polymer concentrations. Providing adequate opportunity for mixing/reaction of the polymer and the water was most apparent during the Sept 9 ditch test, during which TSS levels progressively decreased through the polymer ditch from the inlet to the outlet. This underlines the importance of optimizing the flow rate and system structure to ensure proper mixing and favourable results.

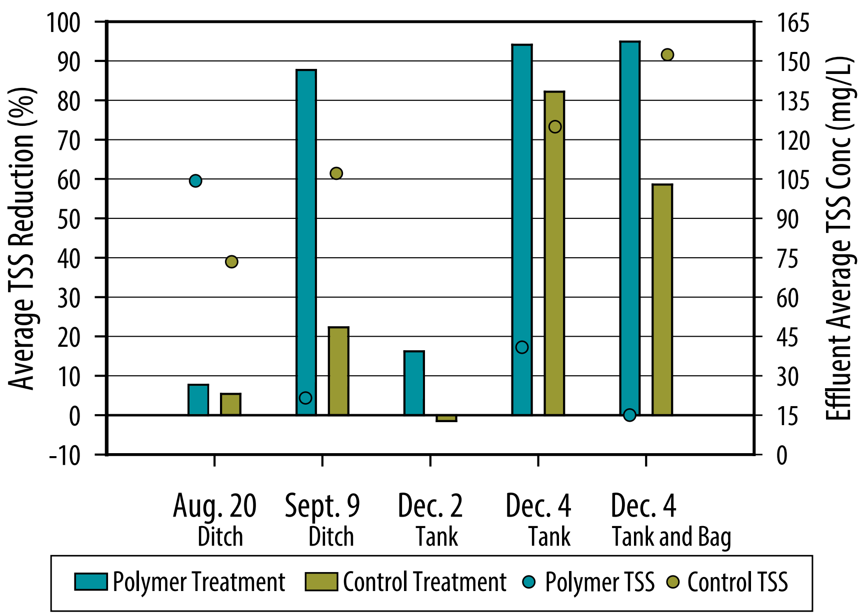


Figure 3: Average percent TSS reduction and effluent concentrations.

The control systems were ineffective because fine particles did not have the opportunity to settle out during the short detention times provided in both the ditch and tank experiments In these systems, factors affecting the gravitational settling of suspended particles, such as flow rate and PSD, are the most important determinants of sediment removal performance. Resuspension of previously deposited sediments occurred over the course of the Dec. 4 experiment, resulting in increased effluent TSS levels. This increase was greater for the control tank, which supports polymer supplier claims that polymer treated sediment is more resistant to re-suspension. This was less apparent in the control ditches, likely because they were used less frequently, and therefore, not as much sediment was available for resuspension.

RECOMMENDATIONS

Polymer System Design and Monitoring

• Anionic PAM delivery systems must be designed for proper dosing, mixing, and final filtration, to prevent flocs from entering receiving waters. The intended location and the expected flow rate are important considerations.

• The chemistry of water to be treated and sediment from the site are the primary data used to determine the type and quantity of polymer and mixing time required. Data provided to the polymer supplier must be true to field conditions.

• During PAM-based construction runoff clarification, the system should be continuously monitored to ensure that no PAM is released to adjacent natural features.

• Risk of accidental polymer release to the environment can be minimized by (i) installing protection surrounding a ditch application or providing extra filtration at the end of the system, (ii) ensuring calculations of the amount of polymer used are accurate and (iii) educating construction staff about the polymer being used.

• Where geotextile bags are used for final filtration, close monitoring is required to ensure that bags are replaced as needed They can fill up quickly when used as part of a polymer system. Caution should be exercised to ensure they do not rupture.

• For ditch systems, the impact of wet weather flows in the ditch must be considered. Any water that flows into the ditch from somewhere other than the inlet, or flows out from somewhere other than the outlet (where there is a final filtration) should be monitored to ensure that polymerdosed water is not released to areas outside the treatment system.

Further Research Needs

• Physical impact of reacted and unreacted anionic PAM deposition in aquatic habitats.

• Effect of anionic PAM on other more sensitive benthic invertebrates in southern Ontario e.g., mussels, mayflies.

• Performance of other viable applications of anionic PAM for treating runoff from construction sites as well as built-out areas.

• Quantification of the extent to which re-suspension is reduced for settled sediment that contains anionic PAM.

• The relationship between the suspended sediment concentration of the water to be treated and the effectiveness of polymer dosing, and identification of the TSS concentration range within which the polymer will perform effectively.

• Performance of anionic PAM for preventing erosion and increasing infiltration on construction sites in southern Ontario.

• Identification and evaluation of visible non-polymer alternatives for clarification of sediment-laden construction runoff during early stages of construction.

• Assessment of potential for PAM in the environment to degrade to the carcinogenic and neurotoxic monomer acrylamide, including identification of which if any conditions in the natural environment can catalyze the reaction.

• Residual acrylamide content in existing PAM products; research in support of development of a local (Canada or Ontario) policy governing residual levels.

• Research in support of the development of a local certification or verification program for PAM products.

REFERENCES

Newcombe, C.P., 1986. Suspended sediments in aquatic ecosystems: a guide to impact assessment. British Columbia Ministry of Environment and Parks, Waste Management Branch, Victoria.

Wright Water Engineers and Geosyntec Consultants, 2007. International Stormwater BMP Database FAQs: Why does the International Stormwater BMP Database Project omit percent removal as a measure of BMP performance? Online document http://www.bmpdatabase.org/Docs/FAQPercentRemoval.pdf

Lenhart, J.H., 2008. BMP Performance Expectation Functions: A Simple Method for Evaluating Stormwater Treatment BMP Performance Data. Florida Water Resources Journal, pp 28-39.

For more information on STEP's other ESC initiatives, or to access the full report for this study, entitled Performance Evaluation of an Anionic Polymer for Treatment of Construction Runoff, visit us online at www.sustainabletechnologies.ca

This communication has been prepared by the Toronto and Region Conservation Authority's Sustainable Technologies Evaluation Program. Funding support for this study was provided by the Toronto and Region Remedial Action Plan, City of Vaughan, Regional Municipalities of York and Peel, Environment Canada, Fisheries and Oceans Canada, and the Great Lakes Sustainability Fund. In-kind support was provided by the Ontario Ministry of Environment, Applied Polymer Systems Inc., Clearflow Enviro Systems Group Inc., and Aquatech Dewatering Company.

Toronto and Region Conservation *for* The Living City