Technological Solutions for Erosion Control and Water Clarification using Polyacrylamide (PAM) and PAM blends

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Abstract

Years of research, corporate publications, patents and trademarks have led to a greatly improved and cost efficient erosion control technology. Development of new polyacrylamide (PAM) blends and delivery methodologies has resulted in a whole new class of in-situ erosion control and water clarification tools. Multi-disciplinary environmental industry projects for mining, construction, water treatment and biological research have proven this class of Best Management Practices (BMPs).

Practical, efficient and cost effective methodologies have been developed that utilize water-soluble, PAM chemistry to routinely reduce erosion and runoff turbidity by over 95 %. These methodologies significantly improve the performance derived by agriculture technologies currently in use within many countries. This performance advancement derives from the precise correlation between polymer selection and target soil lithology characterization. Resultant soil particles are flocculated, agglomerated and chelated in-situ, with significantly reduced suspended solids, metals, TMDLs and NTU values of runoff waters entering riparian water bodies.

This presentation provides to attendees the principles that enable realization of the desired performance, including: 1) basic polymer-soil chemistry fundamentals, 2) application technologies, and 3) economic & environmental considerations. The information provided will allow erosion control professionals to determine if this technology is suitable for the various mining reclamation, forestry or construction site applications, and, if so, how to economically achieve storm water quality that facilitates compliance and meets regulation.

Introduction

Chemical treatment of stormwater and wastewater using coagulants and polymers has been extensively used within the mining industry (Carter & Schiener, 1991) and has only recently begun on a broader scale with municipal, construction and agricultural runoff. The recent expansions of National Pollution Discharge Elimination System (NPDES) phase II requirements have increased the demand for higher water quality discharges of stormwater. Conventional mechanical stormwater BMPs have shown limited or non-compliant capability to remove or reduce nutrient, colloidal clay and metal contamination from stormwater. These colloidal constitutes within stormwater have driven researchers to expanding the scope for the use of chemical treatment systems. Engineering designs using Stokes Law have adequately addressed the heavier particulate but continue to fail in performance of removal or adequate reduction of the colloidal fractions and metals. Environmentally safe polymer and polymer-coagulant combinations have shown significant reductions of metals (Iwinski, 1995), nutrient (Chastain, Vanotti, and Wingfield, 2004) and colloidal clays. (Sojka, Lentz, Bjomberg and Aase, 2003)

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Polymer (PAM) Usage

The usage of PAM type polymers has become the norm for many construction site stormwater treatment systems. The most common method is simply the application of a spray or dry powder application to a disturbed soil surface to reduce the solubility of the clays into the stormwater at the source. This method may be the most effective in reducing the bulk of clayey particulate (Sojka, Lentz, Bjornberg and Aase 2003) although most PAMs that are used today are marketed as a “one PAM fits all” method. This method works poorly as PAMs must be site specifically tested for each clay type found in the soil, similar to procedures used in water treatment industries. The use of single PAMs in a broad range of settings has not always yielded satisfactory results. These inappropriate applications of polymers have slowed the acceptance of polymer stormwater treatment technologies.

Current engineering practices usually do not teach water quality treatment techniques. Educational seminars and workshops are increasing and better performance is beginning to be seen in the field. Engineering details are beginning to appear (Figure 1) on design plans showing the correct methods of performance testing and application along with requirements of certified toxicity reports.

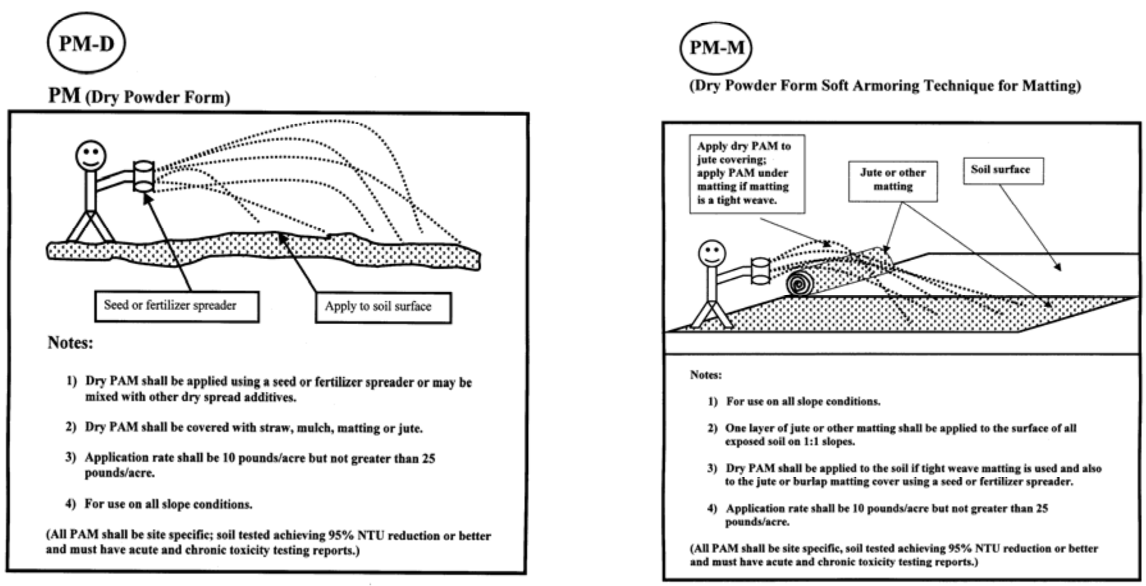

Figure 1 Application of PAM powder

PAM Log or Block Forms

The use of PAM logs or block formulations may be the most effective methods for colloidal clay, nutrient and metal treatment in flowing water due to the ability to add reactive chemicals that will act upon the desired target clay, nutrient or metal. Flow through column studies conducted using site specific PAM formulations for waste rock have shown removal rates of 99% zinc, 99% copper, 99% silver, 54% phosphorous and 71% manganese (Iwinski, Condon and Stein, 1996). An added benefit of these formulation is the ability of the formulated molecules to utilize lignin or chelate reaction with metals, nutrient and clays which further reduce solubility and enhance more rapid settling characteristics (Yoon, Moon, Park and Pask, 1994). Liquid injection or powder feeding systems are either quite costly or cannot be implemented in remote sites where power is unavailable. Cationic PAMs or biopolymers derived from chitin have shown significant toxicity issues to aquatic organisms (Orme and Kegley, 2004) and their use is commonly prohibited for most in-situ applications. Anionic PAMs show toxicity at level orders of magnitude above the dosing requirements, thus environmentally friendly.

PAM logs or blocks may be constructed in various ways to allow varying degrees of dosage application. This allows for multiple passive types of applications and a large degree of versatility for construction sites, stormwater and metal contaminated water flows. Particulate that is formed from these types of applications may be settled using conventional ponds or constructed wetlands. Settling times of particulates once reacted with the PAM logs or blocks are greatly reduced allowing for much smaller pond sizes, which reduce the area footprint of the pond and overall cost. This has prompted engineers to utilize this concept into project designs where a conventional pond may not be used due to available land size restrictions or in cases where water quality issues may arise. This new capability has allowed higher density development and land use where only a few years previous were not considered due to high construction costs or environmental risk.

New BMP Systems

The increased effectiveness of site specific PAM blends have caused increased demand for methods to further enhance runoff and stormwater quality. The typical TSS or NTU reduction from a properly applied PAM blend application will result in a decrease of three orders of magnitude (Price and Company, 2004, 2005). Although significant, this may not provide adequate performance to comply with many stormwater water quality regulations during storm events. The cause of this is generally the very fine particulate, though reacted and capable of settling, has not had time to settle. One answer to this is the Baffle Grid system (Figure 2), which was invented for this purpose in Alaska in 1993 for metal retention (Iwinski, 1995). The Baffle Grid system has the ability to reduce the very fine reacted particulate to three orders of magnitude during a storm event. (Figure 3) The Baffle Grid system mimics the design application of an inclined slant plate clarifier (Pan American Environmental, 2005) and an organic filter fabric. Fine polymer reacted particulate collects on the panel surface, build up and falls to the grid floor. What allows this to work on a continuous flowing system is the PAM logs or blocks that has been chemically tested for the lithology within the water and correctly placed upstream.

Figure 2 Baffle Grid system designed for 15,000 + GPM, Atlanta, Georgia

Baffle Grid systems are now used throughout the eastern portion of the United States with these devices being regularly designed into the grading and stormwater plans.

Date	Rainfall (in)	Effluent (NTU)	Plunge Pool (NTU)	Site Discharge (NTU)
4/25/03	2.5	1,582.0	40.5	12.8
4/26/03	3.0	1000.0	37.1	2.6
6/13/03	1.25	1180.0	49.1	34.3
7/02/03	2.5	N/A	18.0	11.4
9/17/04	5.1	N/A	15.5	13.3
11/23/04	2.4	N/A	37.7	21.4
12/10/04	1.5	N/A	31.9	14.1

Figure 3 Chattahoochee Bluffs , Atlanta, Georgia Water Quality Monitoring (selected data for illustration only) Effluent data was discontinued at site stabilization.

PAM Enhanced Soft Armoring

Soft armor techniques are very easy to use and can reduce or prevent rilling and erosion in areas where stormwater and concentrated flows will “cut” the soil. Matting is placed flat to the soil surface and soil stapled in place preventing movement of the matting. Typically jute, burlap or other organic matting having a high surface area is used, as the clay particulate will attach to the fibers of the matting. Geo synthetic, excelsior and turf reinforcement matting (TRMs) are not suitable for this type of application, as they do not have sufficient surface area. Once the correct PAM-soil type is found, the PAM is simply applied to the matting surface. Seed, fertilizer and other soil amendments should be applied to help establish vegetation. This method is very effective in reducing erosion at the source and reducing turbidity loads down slope.

Figure 4   Before and After Soft Armoring application

Stormwater and Retention Pond Level Spreaders

Level spreaders have been in use for quite some time on agricultural applications. The application to stormwater ponds can greatly reduce particulate from leaving the pond when PAM logs or blocks are used within the storm drain drop inlets. The level spreader must be place from side to side across the pond and made of the same type of material used with the soft armor applications. Stormwater enters the pond and is dispersed laterally from side to side, reducing velocity and allowing the PAM reacted fine particulate to adhere to the fabric of the spreader panels. This method can easily be fitted to most existing stormwater retention ponds.

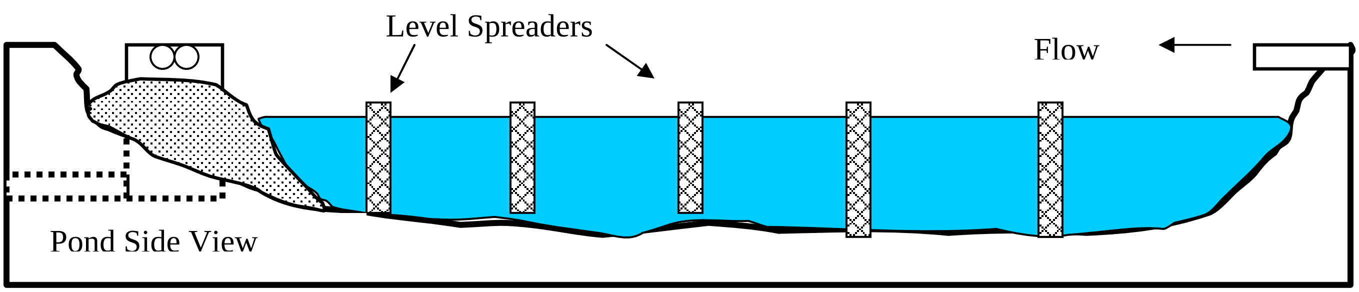

Figure 5 Stormwater and Retention Pond Level Spreaders.

Conclusions

The colloidal fractions, metals and nutrient loads contained in stormwater can be effectively chemically bound with enhanced settling characteristics using pre tested environmentally safe blended PAMs. Fine residue material that does not readily settle can be effectively captured using Baffle Grids, panel level spreaders and soft armor techniques. Stormwater ponds and retention basins may be reduced in size due to decreased settling rates of PAM reacted particulate. Reduced cost of pond construction and greater versatility of land use is now possible with the use of PAM enhanced BMPs.

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