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Polymer Enhanced Best Management Practices for Erosion, Sedimentation and Stormwater

S. R. Iwinski, University of Central Florida, Stormwater Management Academy,
Applied Polymer Systems, Inc. R&D Laboratory
519 Industrial Drive
Woodstock, GA 30189

Abstract: Polymer enhanced best management practices (PEBMP) for erosion, sedimentation control and stormwater will visit a compilation of various quantified BMP systems that have shown significant discharge water quality improvements. A series of case files from Western Canada to South Florida will show various PEBMP methods from prevention of source contamination to stormwater cleanup using dewatering systems.

Background

Polymer Enhanced Best Management Practices (PEBMP) have been used for soil stabilization and conditioning along with stormwater quality for many years and have shown significant improvement over conventional BMPs. (6,12, 14,15,19) PEBMP use has greatly increased in recent years as manufactures continue to add polymers to existing and new products in the form of hydroseeding mulches, soil binders, stormwater clarification devices, inlet protection devices and various soil covers and matting. As the performances of these devices become better, environmental issues are becoming more easily managed and actual costs of erosion and sediment control are reduced due to reductions in E&SC issues and cleanup maintenance.

A significant cost on any land disturbing activity results from the requirement for sediment recovery and site repair. Poorly designed BMPs or improper BMPs that have not been quantified or have been sold under manufactures specifications can only greatly increase the cost to any project. (Fig. 1,2)

Figure 1: Improper Bonded Fiber Matrix

Figure 2: Result of poor soil stabilization

University and government research over the last 10-20 years has resulted in a significant amount of quantification or verification for what BMP systems work best and what type of polymer enhancement results in improved performance of a BMP. (6,15,17,19,20,21)

General Types of Polymers

Many different types of polymers may be used to enhance BMPs. Guars and Gums are routinely used as tackifiers as they "cure or harden" after application and can form a crust that is resistant to erosion. Guars and Gums cannot clarify turbid water and can reduce plant growth due to crusting. They are widely used in hydro mulching and seeding but care must be taken to account for the required curing time. Guars and Gums can also become resoluble when exposed to sustained rain and wet conditions. These polymers are well suited for dryer climates or areas where sustained rain events are unlikely.

Cationic polymers such as amines, amides and chitosan are routinely used in sewage treatment, water treatment and mineral processing. They are highly effective as they can directly bind to negatively charged material such as clay, organic material and metals. Cationic polymers are generally small in size and when bound to their target do not perform well as tackifiers or binders and tend to settle slowly when used for water treatment. Cationic polymers are also quite toxic to aquatic organisms and should never be used in the open environment or allowed to discharge to the environment without complete reaction to the intended target. (2,3,4,7,13,16,20,22)

Anionic polymers are commonly derived from natural gas into polyacrylamide (PAM) although they can also be made from vegetable oils. These polymers are very large and can bind soil and particulate matter very well, they are the most widely used polymers for BMP enhancement today. Typically these classes of polymers have much less toxicity potential to aquatic organisms and are effective in removing metals and turbidity from water. There are hundreds of PAM type polymers and each one reacts differently to the intended target. When the correct polymer type is used the result is very effective and complete resulting in highly increased BMP effectiveness. Incorrect PAM use can result in binding failure, poor water quality conditions and significant reduction of the BMP effectiveness.

Choosing a polymer

The use of any polymer first requires the absence of aquatic toxicity potential no matter what application it may be chosen for. Two basic rules need to be followed to assure that the best performance of the polymer and absence of environmental concerns are met.

First a complete aquatic toxicity report is required following EPA / ASTM guidelines to assure that under any worst case scenario no harm may result from discharges to the environment. MSDS sheets do not require this level of information and should never be used as a substitute. The second rule is that an actual performance test needs to be done to affirm that the correct polymer is chosen for the BMP enhancement. This is quite similar to what is done with jar testing used within water treatment, paper pulp, mineral processing and similar industries.

How Polymer Enhancement Works

Polymer enhancement may utilize several different methods to bind or capture metals, clay, nutrients and particulate. Three basic methods are electrostatic attraction via opposite charges on the target to the polymer, physical binding or encapsulation of the polymer and target and chelation of the target via the polymer. The most common method of the three reactions for PAM based polymers is the "bridging" reaction that uses cations in the soil or water to "bridge" between the anions of clay and polymer.(3,8,14,17,18,20,21) (Fig. 3) It is not uncommon to have all three reactions occurring at the same time when the correct polymer is used.

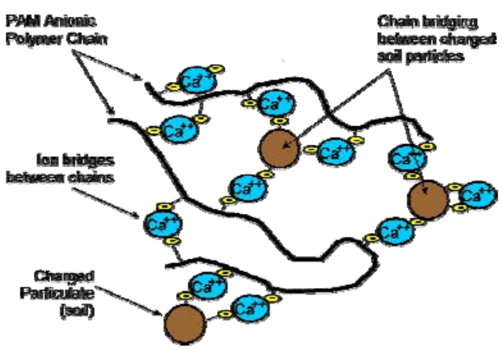

Figure 3: Typical Bridging reaction

Standard BPM materials such as straw matting, mulch, jute and other soil cover materials cannot bind soil to the BMPs alone. When the polymer reactions occur, a matrix is formed resulting in particle "collection" known as agglomeration. (Fig.4)

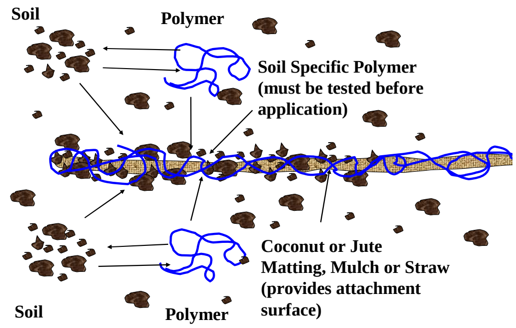

Figure 4: Matrix-agglomeration formation

As the matrix is built the agglomerated particles attach to the BMP material resulting in a chemical-physical bond to the BMP. (Fig 5)

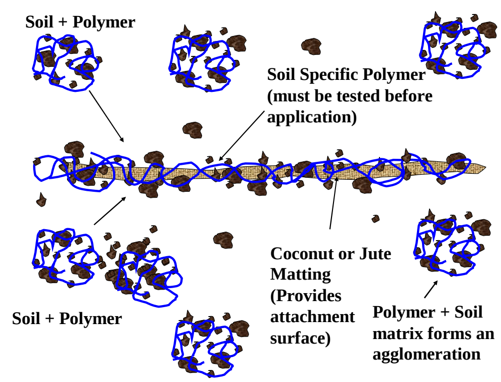

Figure 5: Agglomeration bonding

Once the reaction is complete the agglomerations form a large complex that attaches to the BMP forming a highly insoluble system that becomes highly resistant to erosion or resuspension in a water body. (Fig. 6)

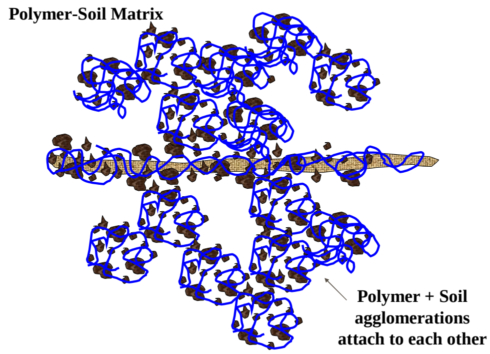

Figure 6: Polymer enhanced BMP

The enhanced BMP has the potential to hold or capture metals, particulate, fertilizer, nutrients and organic matter along with plant seed and other favorable substances that will assist with seed germination and overall stability within a fiber matrix. (10,18,21) (Fig. 7)

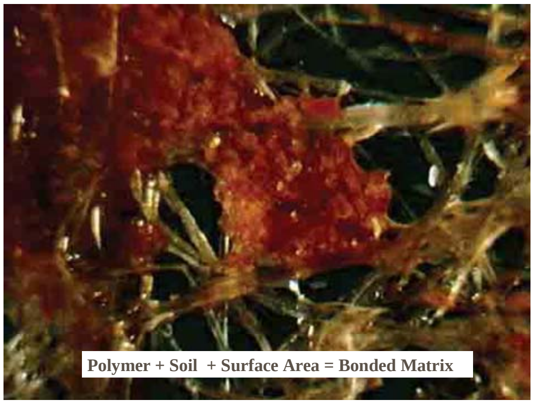

Figure 7: True bonded fiber matrix

Applications

Enhanced Hydro-Mulching & Hydro-Seeding

One common application is hydro-mulching or hydro-seeding. When the correct polymer is added to any existing mulch and applied (fig.9) the bonded fiber attaches to the soil surface and forms a complete bond.

Figure 9: Polymer enhanced hydro seeding

After a few weeks following rain events and normal weathering the polymer enhanced application shows no erosion and very effective vegetation. (Fig10)

Figure 10: Ponds Result of Polymer enhanced hydro-seeding

Polymer Enhanced Soft Armoring

Another common and very effective polymer enhancement is that of "polymer enhanced soft armor" (Fig.11). This system is simply done by adding a soft organic matting material to the surface of such systems as rock checks and applying the correct polymer to the matting.

Figure 11: Polymer enhanced Soft Armor

Normally fine sediment and silts can move through rock check systems and travel to the lowest portions of a ditch system. Once polymer enhanced, the rock check can capture the fine sediment closer to the source resulting in easier maintenance and reduced cost along with highly improved water quality. (Fig 12)

Figure 12: Polymer Enhanced Rock Check

Silt Fence Retention Barrier (SRB)

Another highly effective polymer enhanced system is the Silt Fence Retention Barrier (SRB). This is simply a double row of high flow silt fence (70 gpm/ft sq) with organic filler and the correct polymer powder. Standard silt fence will allow fine sediment through the system resulting in release to the environment and issues with water quality. (Fig 13)

Figure 13: Standard Silt Fence

Once the double row of silt fence has been enhanced to a SRB the system will greatly reduce the fine sediment and increase water quality. These systems are very useful in protecting streams and ponds and are widely used during the grading and grubbing phases of a project. (Fig. 14)

Figure 14: SRB System

Particle Curtains

Particle curtains are highly effective for removing fine particulate and increasing water quality. The particle curtain works on the same basic principle as a lamella clarifier. Once turbidity, metal and particulate react by flowing water moving over and around the correct site specific polymer log or block, the heavier reacted material settles out quickly. The fine residual material will then attach to the surface of the curtain and build up the same as with a clarifier as used in a water treatment plant. (5, 9, 11) As the water flows through the system the water becomes cleaner and the fine material is removed. (Fig. 15)

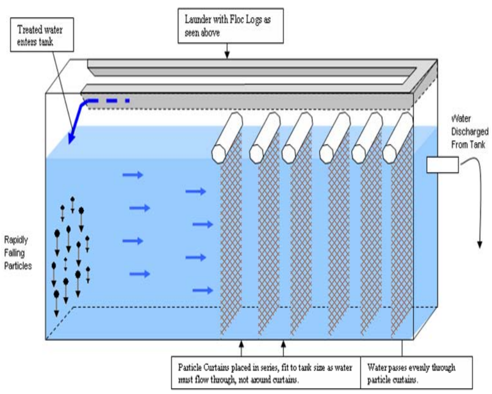

Figure 15: Particle Curtains in a tank system

Particle curtains may be used in open ponds similar to how silt curtains are used. The major difference is the water quality is greatly improved when using the particle curtain. (Fig 16)

Figure 15: Particle Curtains in a tank system

Mud Thickening

Mud thickening and removal is easily enhanced by applying the correct polymer to the mud and mixing the material. This is the same principle as is done in sewage treatment plants. (1) (Fig 16)

Figure 16: Polymer applied to mud

The mud can be thickened very quickly and handled the same as normal soil. Time required for mixing can vary greatly with temperature and water content. (Fig 17)

Figure 17: Mud mixing with polymer

Once the mud is thickened it may be transported as easily as soil and may be used as a soil amendment to stabilize erosive soils and increase vegetation. (Fig 18)

Figure 16: Polymer applied to mud

The resultant stabilization and growth potential greatly reduces cost and increases performance. (Fig 17)

Figure 17: Polymer enhanced mud

Conclusions

Polymer enhanced BMP systems are rapidly gaining acceptance due to their much higher performance over conventional BMP systems. Cost reductions and decreased environmental issues with the use of these PEBMP are a driving factor as construction, shipping and energy costs rise. Future trends will likely require much better performance from BMPs in relation to historical performances along with cost reductions to assure that all users can maintain compliance criteria, not just those who can afford it. Continued testing and quantification of the technology by universities is essential to assure best performance rather than sales dialog or potential misinformation from vendors and manufactures wishing for quick sales. Historically BMPs have been generally designed and used following “cookie cutter” methods resulting in wholly inadequate results. Future BMPs must be site specific for each application and use only “what has been proven” to work.

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