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Controlling Storm Water Induced Pesticide Runoff with Polyacrylamide

By Michael L. Haile, CCA

There are many variations of polyacrylamide being marketed today. . Over 200 million pounds of polyacrylamides is sold annually; about 10% is sold to agriculture mostly to aid water infiltration and to control irrigation induced erosion in furrows. A more recent use is to control soil borne pesticide runoff by controlling sheet erosion and to stabilize agricultural soils. Other uses include the flocculation of silt and clay particles from storm water runoff. The intent of this informal paper is to provide you with some basic knowledge regarding polyacrylamides for use on bare agricultural soils and similar environs to control runoff of soils and pesticides.

Polyacrylamide is a generic term which includes many formulations. This bulletin is focused on the form of polyacrylamide generally intended for use in soil erosion and sediment control which is comprised of a long high molecular weight carbon chain. The common form is the water absorbing or "clump" polymer; the clump polymers will not achieve any noticeable benefits related to storm water management or erosion control. Linear polyacrylamide is often referred to by soil scientists simply as "PAM"; a more accurate chemical description is an "anionic, linear copolymer of Acrylamide and Sodium Acrylate".

PAMs are not all created equal; there are five fundamental physical and chemical characteristics to consider: Polymer type, Charge, Solubility, Toxicity and Quality/Labeling. The other important factors are intangible, these being your supplier's ethics, knowledge, truthfulness, integrity and honesty. The actual application of PAM is simple, but first there are important things to know about PAM beforehand.

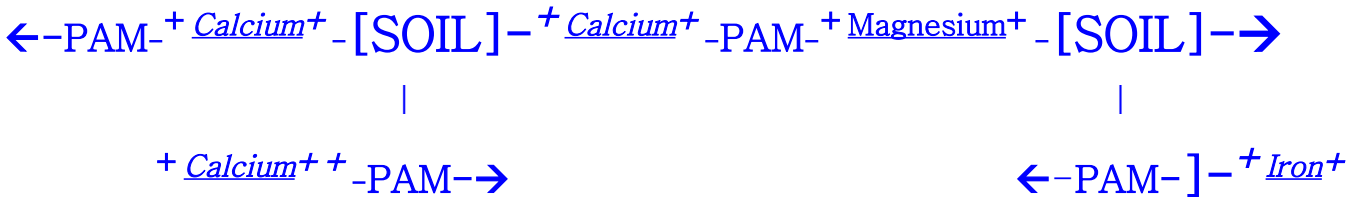
Polymer Type. There are several polymers currently in use in erosion control. Another product often referred to as polyacrylamide is the water holding/absorbing or gel polymers these are not effective in controlling erosion. The water absorbing polymers have little value as soil stabilizers, but can be used to enhance the water holding capacity of a soil when planting tree or vines especially in arid climates. PAM and the water absorbing polymers are compatible when used together and also with many other polymers. Other polymers include natural polymers such as guar and cornstarch, and chemical polymers such as latex, ethylene vinyl acetate (EVA), polybutadiene and poly-vinyl-acetate (PVA). Some of these polymers have applications in other industries as well, including paint, oil drilling, and textiles

As originally formulated, by the base manufacturer, PAM is created as a dry sheet which is then broken up and utilized to create various formulations which includes blocks or disks, crystals, flakes, beads and liquids. The blocks and disks usually have 50-55% active ingredient or "pure PAM" and typically contain 40% polyethylene glycol. The blocks are effective in some situations, such as in controlling furrow erosion, but will not dissolve and release fast enough for most erosion control applications. Most of the dry PAM is about 90% "pure" with remainder being water and urea which is introduced as an aid to solublization. Most of the liquid PAM's contain between 25-55% active ingredient the balance being emulsifying agents and surfactants. The liquids are primarily available in three forms: aqueous solutions, water-in-oil and liquid dispersion polymers. The aqueous solutions are simply PAM dissolved into a volume of water and have a very short shelf life. The water-in-oils contain about 1/3 water and can separate in storage and upon freezing. **The liquid dispersions or LDP formulations are the best choice for most applicators**; you are not paying to transport water, the LDP formulas have a very long shelf life and resist separation in storage including below freezing conditions. All PAM is subject to ultra violet degradation both in storage and after application to the soil.

Charge. All PAM molecules classified by electrical charge. The molecular charge is important as different PAMs will react with things like fertilizers and soil particles, depending on the charge. PAM can be cationic (positively charged), nonionic (no charge) and anionic (negatively charged). **Anionic PAM should be the only PAM used in agriculture and erosion control because it is safe for fish**. The cationic polyacrylamides are very effective soil binding agents but are also very toxic to aquatic life; these have legitimate uses, mostly in oil drilling and are readily available. Cationic PAM is toxic to fish as it attaches to the hemoglobin in the fish's gills causing suffocation; other aquatic organisms may also be affected. Some companies may mix cationic polymer with anionic polymers to "improve" their product. Always buy from a reputable source offering a known brand and ask questions.

An insightful question occasionally asked by our more knowledgeable customers is "*How can a negatively charged molecule bind negatively charged soil particles, for example, most clays? Opposites charges attract and like charges repel - how this does make any sense?*". The answer is found in how the soils work with other charged molecules such as certain nutrients. Applying Calcium to your soil or mixing calcium or any other positively charged materials with solubilized PAM can aid in binding these soil particles and flocculation. The clay particles "hold" positively charge ions such as calcium (Ca^{++}) , magnesium (Mg^{++}), copper (Cu^{++}), zinc (Zn^{++}), and iron (Fe^{+++}). The **positively charged ions form a bridge between the clay particles and the PAM.** Because the PAM is a huge long chain molecule it will "bridge" to multiple clay particles by attaching to these positively charged ions.

it might look something like this:



The PAM - Calcium - PAM and the calcium-PAM-magnesium connections are not typos! It reasonable to assume some cross linking between the polymer molecules occurs on a regular basis especially if calcium or another cat ion, such as iron, is added to the mix!

Solubility. The solubility of PAM is dependent upon the molecular weight. Simply stated, the higher the molecular weight, the larger (longer) the molecule and the lower the solubility. Conversely, those PAMs with low molecular weights are very soluble and will simply wash away. The solubility is also influenced by the percentage of active ingredient; select PAMs with specific molecular weight ranges known to be effective and reliable under real life working conditions. Field test results are more reliable for working conditions than lab tests; the lab tests are the guide - the field tests are the proof.

To help you visualize the effects of molecular weight, picture three buckets each containing about 2,000 yards of plastic (polymer) fishing line: one bucket has the line chopped up into sections 3" long (a low molecular weight); the next has a brand new spool still wrapped in plastic (a very high molecular weight) and the third has 120 pieces about 50 feet long each. Too high of a molecular weight and the PAM (the spool of line) will simply ineffectively sink and settle to the bottom. The low molecular weights (the short sections) are very soluble and just not long enough to bind anything. The PAM must be capable of going into an aqueous solution between the time it is added to the water tank or holding pond and prior to application and have a long enough carbon chain to function properly and bind the soil particles together.

TOXICITY. Due to impurities, there are low grades of PAM known to be carcinogenic (cancer causing). A concern often expressed is that the polymer will break up and return to its monomer components; testing and studies have proven this does not happen. **The real concern is regarding the percentage of residual monomer which is an unreacted portion of the base chemicals that did not form into a co-polymer.** Usually the cheaper the product, the greater the percentage of residual monomer will be present. Some publications mention prices of $2.00 -$5.00 per pound; the better and preferable grades actually sell for $5.00 to $8.00 per pound. **Any PAM product with residual monomer content (RMC) over 0.05% should be considered to be potentially harmful to the end user**. The standard for use in drinking water in the United States is a monomer content of 0.05% or lower. **We recommend the lower RMC (0.025%) for soil stabilization** for two reasons: *first* chances are you, personally, will be handling it; *second* water treatment plants typically use measuring equipment which is much more accurate than those in use in our profession and under more controlled circumstances; in other words the chance of an over application and exposure is greater in agricultural settings than at water treatment plants. So we recommend the safer product for you and your employees - Why not?

LABELING and QUALITY. Most of the issues concerning quality have been addressed above and these should be always adequately addressed on the label and in the sales literature provided to you. If you have questions get them answered before you buy. One of the issues not discussed above is concentration. As you prepare to purchase consider the concentration or percentage of active ingredient. This is often referred to as “pure PAM” and is a simple means of comparing two or more formulations by the price per pound. This is similar to purchasing a pesticide or fertilizer. The label should also include a statement of shelf life for the unopened container when properly stored and should clearly state the monomer content. For use in crops or with seed, it must be approved by the state in which it is to be used; in California this is the Department of Food and Agriculture, and the label should clearly show it is registered as a soil amendment if it is to be used with any crop.
For Non Crop areas CDFA does not require registration.

USAGE. PAM has proven effective in controlling sheet erosion at rates as low as ½ pound per acre and up to 75 pounds per acre. To control furrow erosion the lower rates are adequate. To control pesticide laden soil movement off site, specifically agricultural perimeters, use we suggest a starting rate of about 5 to 10 pounds of "pure PAM" per acre on flat ground and gentle slopes as a starting point. Much depends on the soil being treated. What works on one field may fail - or be considered overkill - at another site. Soil type, structure, condition, use and current cover all play crucial roles in determining rates. For steeper slopes you must use additional BMP (Best Management Practice) to provide a higher level of protection. Application methods vary depending on available equipment. Reduce the rate as you learn what works best on your soils.

When applying any PAM formulation **it is important to realize this polymer reacts very quickly with water and forms a very slippery and gooey mass** when the applicator gets sloppy. Never pour water into the PAM, always gently pour the PAM into the water preferably with agitation. If the tank has mechanical agitation the pump or paddles should be running. PAM should have time to cure on the soil surface at least 24 hours before rainfall, but for the dry and direct ULV applications a gentle rain will be needed to activate the polymer. PAM will control sheet erosion but it will not stop a hillside from moving or hold up to extreme weather conditions. An application should last about three months, less if rainfall is heavy; an application made in the fall should last through the winter if not disturbed by traffic.

Because the use of high quality PAM formulations would be cost prohibitive over an entire field, **focus on field perimeters and high profile areas at risk from pesticide runoff**. This will create working face or buffer between production acres and the smaller but at risk areas such as ditches, creeks and neighboring property. As the PAM is solublized and transported by the moving water it will "glue down" soil particles in its path and settle solids from the fields interior. The primary mode of action is that as sediments are borne by the storm water they become "glued together" by the PAM then sink and are glued to the soil. For large fields you may consider treating strips across the expect flow of water to reduce the sediment load.

The simplest application method is **hand scattering dry PAM** over small areas, it can also be applied with a fertilizer spread mounted on a tractor. When applying dry PAM by hand a normal rate is 40-75 pounds of pure PAM per acre; coverage by dry application is not as effective as liquid applications using a water truck, hence the much higher rates. Because of cost and high rates this method is best suited to very small areas and for emergency situations.

Water trucks are very effective to apply over a large areas, be sure the tank is recirculating to keep the PAM in solution. Because the molecule is much heavier than water it will quickly sink into the sump and the application would be erratic. Dilutions of 1-4 pounds per 1,000 gallons have been successful. Be careful it is very easy to load a water tank with more PAM than can be pumped creating a thick very viscose liquid. We recommend mixing a half load the first time out so that if you have trouble you can dilute it with more water. It is much faster to mix a liquid formulation as the liquid polymer mixes and solublizes more readily the dry products. Allow at least 20 minutes for the solution to completely solublize before applying and longer in cold weather.

The use of modified sprayers to apply PAM is dealt with in "**Ultra Low Volume Application of Polyacrylamide".** Essentially ULV application entails utilizing a slightly modified pesticide sprayer which pulls directly from the undiluted PAM container without adding water. We have found the LDP formulations work best. This method can damage pumps and other parts not designed to pump viscose liquids. If PAM is left to cure inside a pump an expensive pump may be ruined. Spray the rinsate over the application zone. Application is either by a spray boom or hand held nozzles. Screens and filters must be removed, the largest nozzles sizes available are used and the unit must be very thoroughly flushed with clear water when finished. Similar to dry applications in that the coverage on the soil surface is not complete, the rate is typically 40-50 pound pure PAM acre or approximately 10 gallons of the Liquid Dispersion (LDP) formulation.

Controlling Pesticide Runoff

The actual use and methods of polyacrylamide to control run off is relatively simple. After applying a pesticide to your soil, wait until it has dried or soaked into the sufficiently then over spray using the application best suited to your operation. Rates and methods have been discussed above. The PAM does not actually hold the pesticide, instead, it protects the watershed for pesticide runoff by "gluing" the soil particles in place. For most agricultural uses a tank truck or a ULV sprayer will probably prove to be most efficient. PAM is not very effective as a dust control on active haul roads but will help to "winterize" dirt access roads. Do not tank mix the PAM with your pesticide as we are unaware of any PAM registered for this mix. The application of PAM, or any soil polymer, over a fumigated field should be discussed with your local commissioner and Pest Control Advisor, Linwood Supply, Inc recommends against applying PAM over an active fumigation site.

It is very important to understand the chemistry or the pesticide applied and the effects PAM has on soil particles. If the chemical applied is readily soluble in water and is anionic, or does not bind to soil particles, it is reasonable to expect the PAM treatment will have little positive effect and that a different polymer or soil binder should be used. Other polymers include PVA chemistries and natural binders such as soy or cornstarch. If the pesticide is tightly held by the soil particles then the PAM treatment will be effective. The polyacrylamide acts to hold the soil particles not the chemical and a water soluble chemical will not be affected. If the soil physically moves during a heavy flood or collapse of a slope the pesticide, PAM and the soil will move together. If extreme soil movement such as slides are a concern then additional measure should be considered and implemented.

We encourage you to ask your PAM supplier hard questions and to expect truthful, straight forward answers, which might mean the supplier may have to do some homework to find the answer. The truth is, as a supplier, sometimes we have to do our homework too.

The USDA-ARS at Kimberly Idaho has produced a great deal of work centered on using PAM in furrow irrigated crops and similar uses in agriculture. An excellent source of knowledge and innovation with research papers spanning many years is available at their website: **www.nwisrl.ars.usda.gov/pampage**

No single product is the answer to all soil stabilization problems especially when dealing with pesticide runoff. *If it sounds too good to be true*…you know the rest! Other polymers also work well including, cementitious gypsum, polyvinyl acetate, EVA copolymers and there are other effective tools for erosion control such as straw blankets, wattles, and straw mulching or just using crop residues strategically. Allways consult your Pest Control Advisor (PCA) or Certified Crop Advisor (CCA) to determine how a certain herbicide or pesticide binds to a particular soil type when making these decisions and when selecting the pesticide products you plan to use. Consider creating a vegetative bio-barrier or buffer zone adjacent to sensitive areas such as creeks and wildlife areas. Use all of your tools to find the most cost effective methods that provide protection and control of pesticide runoff and soil erosion.

Please feel free to call us directly if you have any questions, comments, and suggestions, or if you need help finding a local supplier. We try to offer a "toolbox" of erosion control products and will be happy to help find the solution to your storm water and pesticide runoff problems.

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Our product guides are written to be technically correct and detailed, but always directed to the end user, and are intended to be understood at all levels of expertise. No site-specific recommendation is made or implied; always consult with local and knowledgeable advisors such as your Pest Control Advisor, Agronomist, University, Certified Crop Advisor or Ag Commissioner for site-specific or more detailed information. Always read the product label and MSDS before buying the product. If you have ANY questions get them answered before opening the container.

Contact Linwood Supply by phone at 707 678-5087 or visit our website at www.LinwoodSuply.com

Controlling Storm Water Induced Pesticide Runoff with Polyacrylamide

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GardenWise, Video. An advertisement from Monsanto promoting an early PAM product, Krillium. technically correct, appears to have been intended for retail sales to homeowners. about 1956. Available on the Linwood Website **www.linwoodsupply.com**

