POLYMER FLOCCULANTS

Polymers flocculants have been used for in various industries for decades – including food processing, aquaculture and mining – as a means of facilitating the separation of solids and liquids. Polymer flocculants are chemicals that adsorb onto suspended particles to form bridges between them, as shown in Figure B2-23. As particles are bound together they form larger aggregate masses, which are then more readily removed from suspension through gravitational settling or filtration (Figure B2-24).

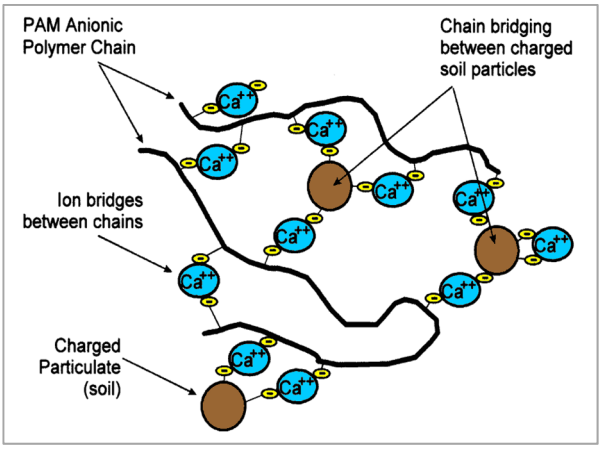


Figure B2-23: Interaction between anionic PAM and soil particles in the presence of calcium (Orts et al., 2002).

Polymer flocculants can be used on construction projects to enhance removal of suspended sediment, particularly in situations where the sediment-laden water cannot be detained long enough to allow particles to settle.

There are various polymer flocculants currently used to promote solid-liquid separations, but only some are suitable for ESC applications. Polymers used for ESC or other environmental applications should be:

- non-toxic to humans and other terrestrial and aquatic organisms;
- effective at reducing water turbidity and/or preventing soil erosion;
- practical for use in the outdoors; and
- otherwise safe.

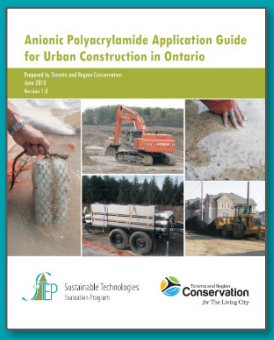
Two of the most common construction runoff clarification flocculants are polyacrylamides and chitosan.

Polyacrylamides (PAM) | PAMs are synthetic organic polymers created through the polymerization of acrylamide. PAMs used in construction stormwater clarification applications are water-soluble (having a linear chain structure) and negatively charged (anionic). Cationic (positively charged) PAMs are also effective flocculants but exhibit a higher toxicity to aquatic organisms than anionic forms. Linear anionic PAM products are typically available in the following three forms: (i) powders used for dry application or for mixing with water, (ii) emulsions that can be added to water, often as part of a hydroseed mix, and (iii) blocks which dissolve into flowing water.

Figure B2-24: Turbidity reduction in water sample following treatment with a flocculant. Before on the left and after on the right.

Chitosan | Chitosan is a cationic biodegradable biopolymer that is produced from a renewable source – chitin – which is found mainly in the exoskeletons of crustaceans and insects and the cell walls of certain fungi. Chitosan is biodegradable and derived from a renewable source. While chitosan is widely used in many commercial products and ingestible dietary supplements, its cationic nature may mean higher toxicity to aquatic organisms relative to an anionic polymer. While toxicity varies among products, in practice chitosan is often used in ways that eliminate

the risk of having residual chitosan in treated water released to natural features. One common example is chitosan-enhanced sand filtration, where sand filters are used at the end of a treatment train (often an active treatment system) as a polishing step which removes any flocculated sediment that remains in suspension. Chitosan residual can also be tested with portable kits that can be useful where effluent discharges directly to a natural feature.



For specific and detailed guidance on using anionic polyacrylamide on construction sites, see Toronto and Region Conservation Authority's *Anionic Polyacrylamide Application Guide for Urban Construction in Ontario* (TRCA, 2013).

The Guide is available in the Sustainable Technologies Evaluation Program Resource Library at:

sustainabletechnologies.ca

Application

Polymer flocculants are best applied to enhance sediment settling when:

- Treatment is required for short-term pumping activities, such that taking the time to construct a BMP with similar sediment removal capacity (e.g. sediment control pond) would be impractical;
- A high sediment removal rate is required but the area available for treatment is too small to accommodate a sediment control pond;
- Water being treated contains a large proportion of fine sediments (e.g. clay) since these are difficult to settle out of suspension
- Water being treated contains certain contaminants of concern that require removal through specific chemical and/or physical processes;
- Site specific policy requirements define more stringent effluent water quality standards than are typical and/or achievable when applying other conventional BMPs; or
- Other conventional sediment control measures have failed to achieve the necessary removal rates.

Design and installation

Product selection

- Selecting a flocculant and determining dosing rates should be carried out in consultation with the product supplier. Dosing rates vary according to the dosing method, product type and its physical form.
- Selection of a flocculant should be based on demonstrated sediment settling performance during bench scale testing using soil and water samples from the site.
- For any flocculants to be used, toxicity data must be available to demonstrate that the product is non-toxic at the intended dosing/application rate. Evidence of this should be available in the product's Material Safety Data Sheet (MSDS) and/or toxicity reports. As a minimum, acute and chronic toxicity data, based on testing by an accredited third party, should be available for the following aquatic

organisms: fathead minnow (Pimephales promelas), rainbow trout (Oncorhynchus mykiss) and water flea (Daphnia magna). The LC-50 concentrations (the concentration of polymer that is lethal to 50% of the sample population) listed in toxicity reports should significantly exceed the maximum anticipated release rate of the product based on the intended use.

- The use of any cationic polymer flocculant for treatment of construction runoff that is being discharged to a natural feature is subject to approval by the local municipality and CA and other agencies involved in regulated discharges from the site. Approval is based on product toxicity data and the intended application method and dosing rate.
- Ensure product labelling and/or packaging is available for the flocculant, which specifies the following:
  - product expiry date
  - use and maintenance instructions
  - safe handling, storage and disposal information
- Any applications of anionic PAM-based products should meet the criteria detailed in *Anionic Polyacrylamide Application Guide for Urban Construction in Ontario* (TRCA, 2013).

Polymers are not a magic bullet

Polymer flocculants can be an important ESC tool, but to be effective they have to be thoughtfully integrated as part of a ***treatment train*** that provides opportunity for ***dosing, mixing and settling.***

System design

- Any flocculant-based construction runoff treatment system should be designed by a qualified individual with knowledge of, and experience with, polymer flocculants.
- A construction runoff clarification system incorporating a polymer flocculant can come in a variety of configurations – such as an open ditch / channel or an active treatment system with tanks – but should always be designed to provide opportunity for the following key system functions:
  - **Dosing:** The flocculant is dissolved into the water being treated at a dosing rate determined based on manufacturer guidance. The dosing rate will vary based on several factors, such as product, type, the flow rate of water and water temperature.
  - **Mixing:** Physical mixing of the flocculant and water will increase opportunity for sediment particles to react and bind together. Passive mixing can be accomplished by allowing the water to flow through barriers that will create turbulence (e.g. rock check dams, baffles). Mixing time required should be determined based on manufacturer guidance.
  - **Settling:** Providing an area for sediment settling following mixing ensures that flocs (i.e. agglomerated particles) will settle out within the treatment system rather than in the downstream area or feature receiving the treated discharge.
  - **Final filtration:** Filtering effluent at the end of the system can provide assurance that flocs that have not settled out of suspension are removed before the effluent is discharged to the receiving area. Suitable filters may include geotextile fabric (e.g. sediment bag) or sand filters depending on the polymer flocculant used and the specific system design.
- Ensure the system discharges to a well stabilized area, with flow dispersion and interruption devices placed as needed. Consider the entire flow path to the receiver and apply stabilization measures along the path as needed.

- Consider air and water temperatures experienced during active use of the system and confirm that the product will be effective at the planned dose temperatures. Some polymer flocculants become less effective at colder temperatures. As a result the dosing rate may need to be increased or an alternative flocculant or treatment method may be required.
- Ensure pumping rates do not shift substantially from the rates estimated during flocculant and system selection and sizing, as the flocculant and filters may be less effective at different flow rates.
- For a multi-barrier approach, always incorporate final filtration for discharge and apply stabilization and energy dissipation in the downstream flow path.
- Keep a spill response kit near the polymer flocculant water clarification system and ensure staff are aware of spills response and reporting protocols.

System siting

- Flocculant based clarification systems should never be sited in natural areas, terrestrial or aquatic features. Where effluent from the system will be discharged to a natural water feature, the distance between the system outlet and the water feature should be at least 30 metres.
- Where siting 30 m away is not possible, consult with the local CA for guidance on siting and monitoring efforts that can be applied to mitigate risk.
- For large installations, like active treatment systems with weir tanks, ensure placement on a stabilized ground surface and consider accessibility by vehicles transporting system components.

Inspection and maintenance

- For systems where water is being pumped, such as in active treatment, inspect daily during active use and keep a record of the inspection. Guidance on active treatment systems is provided in the following section.
- Where flocculants are used in a passive way (e.g. in an interceptor swale), inspections should be carried out on a weekly basis as well as before and after significant rainfall or snowmelt events.

Figure B2-25: Polymer flocculant in gel-block form

- Carry out routine effluent monitoring to verify performance and ensure that effluent quality meets any applicable standards. If contaminant removal performance declines, investigate each system component – dosing, mixing, settling, filtration – to identify the potential source of the problem. If the system is treated pumped water that is being discharged to a natural water feature, cease pumping until performance issues can be resolved.
- The following components should be inspected, if applicable:
    - **Dosing area.** Ensure dosing is occurring as intended. Where solid block forms are used, ensure they are not being coated with sediment, as this can compromise their capacity to dissolve into the water. Also consider block positioning to ensure good contact so that water isn't short circuiting the dosing area.

  - **Filters.** Regular inspection is required to ensure filters remain effective. Where geotextile bags are used for final filtration, close monitoring is required to ensure that bags are replaced as needed. Because they can fill up quickly when used as part of a polymer system, caution should be exercised to prevent rupture.
  - **Sediment settling area(s).** Sediment accumulation should be removed at the appropriate trigger (e.g. 30% height of a sediment retention barrier).

- For ditch / swale systems, inspect for evidence of excessive sediment accumulation and / or erosion, and clean out or re-stabilize as needed.
- Ensure the flocculants are being stored and maintained as specified in guidance from the supplier / manufacturer to ensure ongoing efficacy.
- Ensure staff overseeing the use of the system have a thorough knowledge of proper maintenance.
- Where there is evidence of erosion at the discharge point or along the flow path downstream of the discharge locations, re-consider whether stabilization is adequate to protect against erosion based on the flows.
- Keep MSDS sheets and toxicity reports related to the flocculant used in an easily accessible location on the site.
- Any repair or maintenance needs identified should be repaired within 48 hours or sooner if natural receptors are at imminent and foreseeable risk of adverse impact.

Decommissioning

- Ensure flocculant-treated sediment and any leftover flocculant are properly disposed of.
- Where polymer flocculants left over are suitable for reuse elsewhere, ensure proper handling and storage in accordance with supplier / manufacturer guidance.