InfoBrief: IB03
Polymer Coagulant/Flocculant Aquatic Safety

ProTech General Contracting Services has completed a series of tests to evaluate the toxicity of stormwater treated with polymers to aquatic organisms. As we initiated the development of polymer coagulation/flocculation systems, it became clear that there was little data presently available regarding the toxicity of many common water treatment polymers, particularly under the conditions of typical stormwater projects. Material Data Safety Sheets (MSDS's), for example, present the toxicity of free, dissolved polymer in clean water (containing no suspended material), which is not representative of stormwater or runoff applications in which the polymer is mixed into turbid water. We tested four polymers (two synthetic and two natural) that are currently in use by ProTech as well as other firms:

- Aluminum Chlorhydroxide: $(Al_2Cl(OH)_5$
- Diallydimethyl Ammonium Chloride: DADMAC
- Mimosa bark-based: derived from the bark of the Mimosa tree
- Chitosan (1% solution): derived from chitin, a component of shrimp and crab shells

Test Method

The aquatic toxicity of each polymer was determined according to EPA "Methods for Measuring Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms" (EPA/821/R-02/012, 5th edition). Ninety-six hour static survival tests were conducted on rainbow trout and fathead minnow, and 48 hour static survival tests were conducted on daphnia magna.

Water for the test was collected from a working jobsite in the Sacramento Valley, which had a turbidity of >1000 NTU with high levels of iron oxides and colloidal materials. Untreated water was tested as a control. Water was treated with each polymer at the optimum dosage (as determined by the dose/response testing – refer to **ProTech Infobrief IB04: Polymer Coagulant/Flocculant Stormwater Treatment Performance**), and at 2X the optimum dosage (to simulate a 2X overdose).

Aquatic Toxicity Test Summary

			% survival		
Polymer	Dosage (ppm)	Turbidity (NTU)	Daphnia Magna (48 hour)	Rainbow Trout (96 hour)	Fathead Minnow (96 hour)
Control	0	>1000	95	100	90
$Al_2Cl(OH)_5$	75	38	95	100	95
	150	29	95	100	100
DADMAC	25	2	95	100	100
	50	5	95	100	100
Mimosa Bark	50	66	95	100	95
	100	41	100	100	100
Chitosan 1%	1100	53	100	100	100
	2200	25	100	100	100

As the Aquatic Toxicity Test Summary table indicates, each of the four tested polymers showed survival rates of 95-100%, equivalent to or exceeding control sample results, for both optimum and 2X doses. Therefore, none of the polymers exhibit toxic effects towards daphnia magna, rainbow trout or fathead minnow. The results demonstrate that, when properly applied, any or all of the polymers can be safely used in a stormwater treatment system, and that there is a minimum 2X margin of safety in dose rates.

LC50 Values

LC50 values (i.e., 50% lethal concentration, or the concentration at which 50% of test organisms are killed) of the free polymer in clean water (i.e., not treated effluent) are presented here. Note that free polymer is essentially not present in treated effluent, as the data above indicates (otherwise toxic effects would almost certainly be observed in the treated effluent tests). In a stormwater treatment scenario, the LC50 data is relevant to a worst-case system upset, in which a volume of free polymer is somehow released to receiving waters. The LC50 values presented here were compiled from the manufacturer's MSDS's.

More importantly however, the comparison of LC50 values points out important variations between polymers, such as the differences between natural versus synthetic polymers.

Polymer LC50 values
(mg/L)

Polymer	Daphnia Magna 48 hour	Rainbow Trout 96 hour	Fathead Minnow 96 hour
$Al_2Cl(OH)_5$	>5000	390	517
DADMAC	17.5	0.49	1.65
Mimosa Bark	258	Not Available	1.3
Chitosan (pure solution)	13.7	1.1	6.4

Note that the $Al_2Cl(OH)_5$, a synthetic polymer, is by far the least toxic, and is in fact less toxic than some household cleaners. Chitosan is approximately equal in toxicity to DADMAC with regard to rainbow trout, which is generally considered a sensitive species. Note also that Chitosan is considered a hazardous substance according to federal Resource Conservation and Recovery Act (RCRA) standards (due to acidity, at a pH of about 4), while many synthetic polymers such as DADMAC are not RCRA hazardous.

Summary

The four polymers tested here exhibit no aquatic toxicity when correctly dosed. No toxic effects were observed at up to a 2X overdose, which was the limit of the study. Therefore toxic effects are only likely to occur at >2X overdose. The LC50 values do indicate that all polymers are potentially toxic when overdosed at sufficiently high levels. However, it should also be noted that in the event of an overdose, excess polymer would quickly react with background sediments, greatly reducing potential toxic effects.

These results point to the necessity of an accurate and reliable polymer metering system. The metering system is the critical link in a stormwater treatment system. Any polymer can be safely applied just as any polymer can be toxic if not properly used. Proper polymer dosage is also critical in order to optimize clarification efficiency and minimize polymer consumption. Because the suspended solids level of stormwater varies with flow and storm events, polymer dose must be precisely metered in proportion to suspended solids levels. For more information, refer to **ProTech Infobrief IB06: Polymer Coagulant/Flocculant Control Systems**.