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EFFECTIVE STRATEGIES FOR RESIDUAL POLYMER AND AQUATIC TOXICITY TESTING FOR DREDGE SLURRY DEWATERING

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ABSTRACT

Chemical conditioning is typically required to facilitate the solids and water separation in the vast majority of dredging and dewatering operations. Even with the best efforts in optimizing the chemical dose, a small fraction of the polymer may be released in the filtrate water after the dewatering operations. Site conditions and regulatory requirements specific to a particular location may dictate that aquatic toxicity testing of the discharge water be completed on individual projects.

After several products and/or combinations of products are tested in bench scale jar tests to determine the most effective products and the associated dose(s), a larger scale dewatering test is completed to determine or verify the suitability of the dewatering technology selected. The example projects discussed for this presentation utilized geotextile containers and the tests were completed accordingly. The geotextile container filtrate collected from the laboratory scale tests was subjected to a series of aquatic toxicity tests based on regulatory agency requirements.

Protocols for aquatic toxicity tests typically require acute and/or chronic toxicity test assessments on a representative sample of filtrate water after conditioned with a specified chemical. In some cases, a specific dilution with site water will be included with the procedure to simulate a mixing zone. The species selected for testing will be based on location, salinity, and other factors. It may be necessary to perform the aquatic toxicity testing using more than one chemical conditioning program.

The regulatory agency will typically approve the chemicals at the dose used in the testing. Additional toxicity testing may be required during operations. Some projects have residual polymer testing requirements. Qualitative testing is typically done in the field as a gross determination of polymer present in the water. The quantitative test is a more precise test meant to be conducted in a laboratory setting under controlled conditions.

Keywords: Chemical, conditioning, regulatory, acute toxicity, chronic toxicity, whole effluent toxicity

INTRODUCTION

In order to effectively dewater dredged material, chemical conditioning is required. The most effective chemical conditioning program is determined by extensive bench testing. The selection of products is based on the project requirements and objectives. In many cases, two or more products are required to optimize the conditioning program.

During the dewatering operations, efforts are made to minimize the polymer use for several reasons. Even with the best efforts to optimize the use of chemical products, a small fraction of the polymer may not be captured with the solids and is released with the water. It has been demonstrated that the product will attach to any available solids in the receiving water. However, the products have toxic effects of aquatic life and any portion that is not rendered inactive by attachment to available solids has been shown to be harmful.

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The material safety data sheets for the products typically contain basic ecological and toxicological information. Additional aquatic toxicity testing may be required using the water released from a simulated dewatering operation. The procedures for sample collection and testing are determined prior to testing. The products, application rates and doses are determined by testing. Samples for initial testing are collected by simulating the dewatering technique to be utilized for the specific dredging application. The aquatic toxicity tests are conducted according to the protocols prescribed by the regulatory agencies.

In certain cases, the residual polymer is measured in the filtrate water released. This measurement can be based on samples collected directly from the dewatering operation or in some cases is based on samples collected at prescribed locations in the water body after the filtrate is released to the water body. The procedures for qualitative and quantitative testing are available to determine the presence of residual polymer and the amount of residual polymer in a specific sample.

CHEMICAL CONDITIONING

Based on the primary project objectives, such as dewatering efficiency, filtrate water clarity, contaminant removal or other objectives, the most effective chemical conditioning program is determined by bench testing. The sample solids concentration and other parameters are determined and required dilution is made to simulate dredge slurry with site water. The dry weight solids concentration of the dilution is also determined according to U.S. EPA Method 160.2.

Several products are evaluated in bench scale tests to determine the most effective product or combination of products to meet the project objectives. These evaluations are based on several factors including water release rate, water clarity, and flocculent appearance. These factors are used to compare the various products to isolate the most effective products and doses.

Chemicals most commonly used to enhance dewatering in dredging applications are:

1. Organic Flocculents
2. Organic Coagulants
3. Inorganic Coagulants
4. Hybrid Chemistries

The application of the chemicals is typically done by injection into the dredge line. Based on the mixing energy requirements or restrictions determined during the bench testing, the injection location relative to the dewatering mechanism can be placed. The effectiveness of the conditioning is frequently checked using a sample port placed downstream of the chemical injection. To optimize the application of chemical, the feed rate can be automatically adjusted based on variances in slurry flow rate and solids concentration.

AQUATIC TOXICITY TESTING

The National Pollutant Discharge Elimination System (NPDES) permitting authorities use Whole Effluent Toxicity (WET) testing program as one of the tools for achieving the Clean Water Act’s prohibition of the discharge of toxic pollutants in toxic amounts. WET is defined as the aggregate toxic effect to aquatic organisms from all pollutants contained in a facility's wastewater (effluent) (54 Federal Register (FR) 23868 at 23895, June 2, 1989). WET testing methods have been developed to measure wastewater's effects on specific test organisms' ability to survive, grow and reproduce. These test methods were promulgated in 1995 and added to the list of U.S. EPA methods approved under Section 304(h) of the CWA (40 CFR 136) for use in the NPDES program.

Federal regulations establish different approaches for implementing a water quality criterion for toxicity in NPDES permits, depending on whether the criterion is expressed in a numeric or narrative form. States that have not adopted a numeric criterion for WET are expected to interpret the State narrative criterion so that the appropriate effluent limits, including any necessary toxicity numeric limits, can be established. States typically identify the method they intend to use in regulating toxics based on narrative criteria and describe how their toxics control program will protect aquatic life and attain the narrative criterion. Examples of some of the WET specific issues addressed in State toxic control programs include the following:

- how critical low flow and effluent dilution series are determined;
- receiving stream aquatic life use designations;
- frequency of monitoring;
- use of marine species or freshwater species for testing;
- sample type, test type, and biological and statistical endpoints; and
- conditions under which acute or chronic testing is required.

For the Southern Shores dredging project, treated water was discharged to a tidally influenced portion of the Dick White Bridge Channel. The State of North Carolina bases WET limitations upon the instream waste concentration (IWC) during conditions of maximum permitted effluent flow and 7Q10 receiving stream flow. The IWC for the Southern Shores project was determined to be 100 percent. In keeping with the State standard for facilities with IWC values greater than or equal to 0.25 percent, the facility was required to demonstrate that treated effluent was not chronically toxic at 100 percent.

For this application, the State required the City of Southern Shores to conduct a five concentration, pass/fail chronic toxicity test using the marine invertebrate, mysid shrimp (*Americamysis bahia*). Each of the five test concentrations consisted of 100 percent receiving water treated with a combination of water additives, bracketing the target application rate. An additional receiving water concentration without the water additives served as a negative control. A concurrent positive control consisted of aged synthetic seawater.

Per U.S. EPA Method 2002, the chronic test was conducted using 250 milliliter (mL) polypropylene containers containing 150 mL of control water or appropriate test solution. Five, seven day old test organisms were randomly introduced into each test chamber with eight replicate chambers per treatment. Organisms were fed 0.2 mL of a concentrated suspension of less than 24-hour old live brine shrimp nauplii (*Artemia* sp.) daily during the test. Organism survival was determined daily by enumerating of live myisds. Survival was defined as any body or appendage movement. At the termination of the test, mysids in each test chamber were counted, dried, and weighed to the nearest 0.01 milligram (mg).

The test was conducted at a temperature of 25 $\pm$ 1 degrees Celsius (°C) under fluorescent lighting with a photoperiod of 16 hours light and 8 hours dark. Water quality measurements consisting of dissolved oxygen, pH, salinity, and temperature were performed daily on selected treatments.

Following termination of the test, statistically significant differences (P=0.05 or 0.01 depending on test endpoint) in mysid survival and growth were determined between the receiving water control and the various treatments. All statistical analyses were performed using the ToxCalc Version 5.0.23 software program.

To demonstrate compliance with the imposed discharge limitations, two sets of chronic toxicity tests were conducted during September 2010, on varying concentrations of Solve 3 and Solve 9330. The initial test incorporated a five concentration matrix of Solve 3 and Solve 9330 with concentrations ranging from 2.8 pounds of Solve 3 and 0.8 pounds of Solve 9330 per dry ton of product to 7.8 pounds of Solve 3 and 1.7 pounds of Solve 9330 per dry ton of product. The results from the initial exposure revealed no adverse survival effect to the five product combinations. Survival ranged from 79 to 100 percent, compared to 92.5 percent in the receiving water control (Table 1). Growth was adversely effected (P=0.05) in all five treatments and ranged from 0.140 to 0.247 mg per organism, compared to a control of 0.298 mg per organism (Table 1). Based on the adverse growth effects, a second set of samples were prepared and tested.

In the second set of samples, the concentration of Solve 3 was held consist at 4.5 pounds per dry product and concentration of Solve 9330 was varied from 0.16 pound to 0.8 pounds per dry product. Following the second exposure, mysid survival was again unaffected and ranged from 92.5 to 97.5 percent, compared to a receiving water control response of 95 percent (Table 2). Mysid growth ranged from 0.281 to 0.324 mg per organism; compared to a receiving water control performance of 0.336 mg per organism (Table 2). Unlike the initial test, adverse mysid growth effects (P=0.01) were limited to the maximum concentration of Solve 9330 of 0.8 pounds per dry ton of product. Mysid growth in the four lower concentrations of Solve 9330 was unaffected and resulted in a non-toxic response.

Table 1 - Data Summary of September 3 – 10, 2010 *A. bahia* Chronic Toxicity Test

Concentrations (lb/dry ton product)	Survival (%)	Growth Average Wt./ Organism (mg)
Laboratory Control	95	0.301
4.5 lb Solve 3 w/ 1.7 lb Solve 9330	80	0.140*
6.1 lb Solve 3 w/ 1.7 lb Solve 9330	79	0.140*
7.8 lb Solve 3 w/ 1.7 lb Solve 9330	87.5	0.188*
4.5 lb Solve 3 w/ 0.8 lb Solve 9330	95	0.247*
2.8 lb Solve 3 w/ 0.8 lb Solve 9330	100	0.240*
Receiving Water Control	92.5	0.298

* Statistically lower when compared to the control or the dilution control (P=0.05)

Table 2 - Data Summary of September 17 – 24, 2010 *A. bahia* Chronic Toxicity Test

Concentrations (lb/dry ton product)	Survival (%)	Growth Average Wt./ Organism (mg)
Laboratory Control	95	0.364
4.5 lb Solve 3 w/ 0.16 lb Solve 9330	95	0.317
4.5 lb Solve 3 w/ 0.32 lb Solve 9330	92.5	0.313
4.5 lb Solve 3 w/ 0.48 lb Solve 9330	97.5	0.298
4.5 lb Solve 3 w/ 0.64 lb Solve 9330	97.5	0.324
4.5 lb Solve 3 w/ 0.8 lb Solve 9330	95	0.281*
Receiving Water Control	95	0.336

* Statistically lower when compared to the control or the dilution control (P=0.01)

RESIDUAL POLYMER TESTING

When requested or required, the residual polymer can be determined according to "*Determination of the Presence of Polymer Using the Flocculation Method*". This procedure includes qualitative and quantitative methods. The qualitative test is normally completed in the field as a gross determination of the polymer present in the sample of water. This can also be used as a comparative test for estimating the approximate quantity of residual polymer

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within a certain range. The quantitative test is more precise and is meant to be conducted in a laboratory setting under controlled conditions.

Initial data points are determined by using known concentrations of the flocculent and performing the test according to the method described above. The data points are then graphed and a best fit curve is added as shown in Figure 1. Samples collected are tested in the same manner and the settling times are plotted on the curve to determine the residual polymer present. Table 2 shows the initial testing to create the data points on the left and the testing of the samples collected in the field on the right. Figure 2 illustrates the testing in a photograph showing how the settling times vary with the amount of residual polymer present.

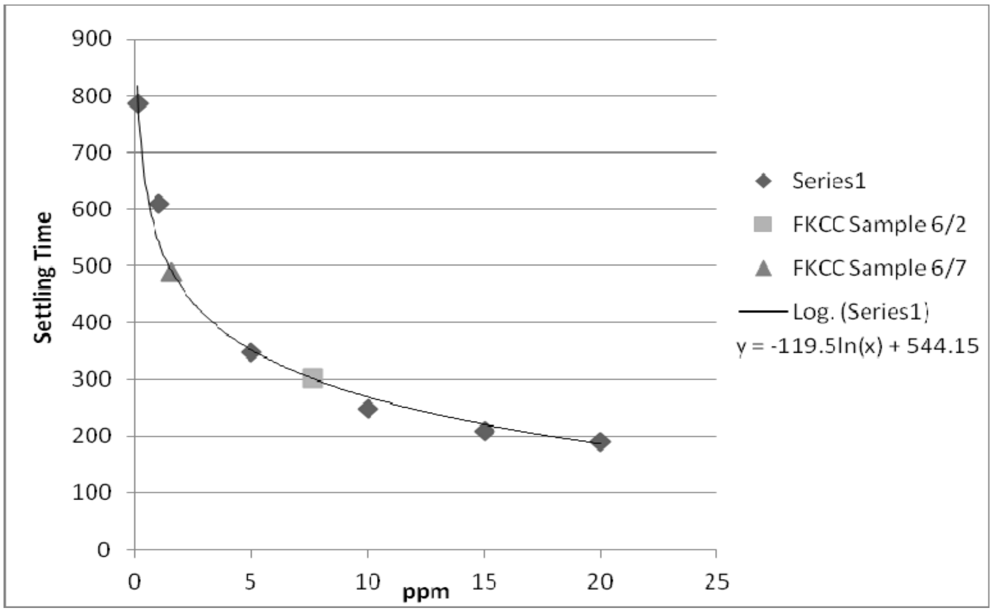

Figure 1. Residual polymer testing results.

Table 2. Data summary of residual polymer test.

P.P.M.	Settling Time (sec)
25	158
20	190
15	209
10	248
5	348
1	609
0.1	787
0	815
FKCC Sample 6/2	302
FKCC Sample 6/7	490
FKCC Sample 6/14	>1500
FKCC Sample 6/21	>1500
FKCC Sample 6/29	>1500

Date	Settling time	PPM
6/2/2010	302	7.6 ppm
6/7/2010	490	1.56 ppm
6/14/2010	>1500	0 ppm
6/21/2010	>1500	0 ppm
6/29/2010	>1500	0 ppm

Figure 2. The Flocculation Method, presence of polymer increases settling rates.

CONCLUSION

Current regulatory trends in the dredging and dewatering industry dictate that approval of dewatering chemical products is required. The regulatory agencies for individual states have variable requirements for these approvals. In order to provide the most effective products that will meet the environmental suitability standards, the type of testing presented will continue to be required. We anticipate that this specific testing will be used to satisfy the growing desire to regulate these products. With the proper testing prior to and during the project implementation, along with the use of the most effective chemical feed systems, the chemical conditioning can be optimized for dewatering dredge slurry residuals.

CITATION

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