

Results of GSI Bench-Scale (Small-Scale) Tests

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DISCLAIMER: GSI's bench-scale tests do not by themselves provide adequate information to assess a prospective ballast treatment's ability to meet a particular discharge standard or to achieve environmental soundness under shipboard application. Instead these tests provide initial insights into possible strengths and weaknesses of the treatment concentrations tested under the conditions tested.

For more information on GSI's bench scale testing visit www.greatshipsinitiative.org.

GSI BENCH TESTS ON CHLORINE

For the full write-up of GSI tests on chlorine, including experimental methods and results, please see <http://www.nemw.org/GSI/GSI-BS-P-TR-Chlorine.pdf>. Please note that the results summary below is intended to provide an overview of treatment characteristics from the bench scale experiments. Results are drawn through interpolation of the quantitative measurements and survivorship observations.

THE TREATMENT PROCESS

What is the proposed treatment process?

Sodium hypochlorite solution (i.e., common household bleach) consisting of approximately 5.25 % sodium hypochlorite (NaOCl) and 94.75 % water.

What is the proposed application?

For use in emergency situations to inactivate viral hemorrhagic septicemia (VHS) virus or similar pathogens entrained in ballast water.

What is the proposed application dose, if any?

Approximately 3-3.5 mg/L of sodium hypochlorite solution to be metered in at ballast uptake, or added to full ballast water tanks. A neutralizing agent such as ascorbic acid (vitamin C) would be added to the tanks after an exposure period as a dechlorination agent prior to or upon discharge. The applicant recommended an ascorbic acid concentration of three times the applied chlorine concentration.

RELEVANT CHALLENGE CONDITIONS

Which environmental variable of those tested (see below) appeared to influence treatment performance and/or degradation the most?

Dissolved Organic Carbon (DOC)

Light

Temperature

What other environmental variable(s) appeared to have some influence as well?

Dissolved Organic Carbon (DOC) Light **Temperature**

What environmental variable(s) appeared to have no influence?

Dissolved Organic Carbon (DOC) **Light** Temperature

GSI DOSE EFFECTIVENESS FINDINGS FOR CHLORINE

Dose effectiveness testing involves evaluation of treatment effectiveness on robust species across freshwater taxonomic categories. Species tested appear in the list below.

Which of the species tested under environmental variable(s) most challenging to the treatment system had less than 1 % survival within 2, 24 and 48 hours of treatment at a dose less than or within the proposed dose range?

Major Taxonomic Group	Species	Less Than 1 % Survival		
		2 Hours	24 Hours	48 Hours
Algae	<i>Selenastrum sp.</i>	NO	NO	NO
Zooplankton (Cladoceran)	<i>Daphnia magna</i>	NO	YES	Not measured
Zooplankton (Copepod)	<i>Eucyclops sp.</i>	NO	NO	NO
Zooplankton (Rotifer)	<i>Branchionus calyciflorus</i>	YES	Not measured	Not measured
	<i>B. calyciflorus cysts*</i>	Not measured	Not measured	YES
Bacteria	Total Coliforms	YES	YES	YES
	<i>E.coli</i>	YES	YES	YES
	<i>Enterococcus</i>	YES	YES	YES
	Heterotrophic Bacteria	NO	NO	NO

*Resting egg survival is scored as number hatched.

Which freshwater species tested was most vulnerable to the treatment, and which was most resistant to the treatment proposed by the applicant?

Adult rotifers (*Branchionus calyciflorus*), total coliforms, *E.coli* and *Enterococcus* were the most vulnerable; algae (*Selenastrum sp.*), copepods (*Eucyclops sp.*) and heterotrophic bacteria were the most resistant.

Other observations related to dose effectiveness tests of this treatment.

Organisms tested in freshwater with low dissolved organic carbon (1-2mg/L) exhibited high rates of mortality within two hours of treatment. Chlorine demand by the water must be overcome before chlorine will inactivate test organisms.

GSI DEGRADATION AND RESIDUAL TOXICITY FINDINGS FOR CHLORINE

How long did it take for the dose that achieved 99 % mortality for all test species to degrade to below detection?

No dose achieved 99 % mortality in water with higher amounts of dissolved organic carbon (DOC). Chlorine was rapidly consumed by the DOC in the water in approximately 15 minutes.

Did treated water that degraded to below detection and/or was neutralized according to the proposed treatment still have acute toxicity? If so, what types of organisms were sensitive to the toxicity?

There was also no acute toxicity detected in these tests associated with 3 mg/L sodium hypochlorite solution followed by neutralization with 9 mg/L of ascorbic acid. Our limited chronic toxicity analysis also did not detect an effect. It should be noted however that much further testing would be necessary to conclude with confidence whether or not chronic toxicity would occur as a result of this treatment.

What specific constituent of the treatment process appeared to cause this toxicity?

It appeared to be the ascorbic acid used to neutralize the chlorine that caused the chronic toxicity.

Other observations related to residual toxicity.

Residual acute and chronic toxicity were detected in association with a high level of ascorbic acid tested (75 mg/L).

MORE INFORMATION

Entire report available at: <http://www.nemw.org/GSI/GSI-BS-P-TR-Chlorine.pdf>.

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