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

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, please visit www.greatshipsinitiative.org.

GSI BENCH TESTS ON SODIUM HYDROXIDE (NaOH)

For the full write-up of GSI tests on sodium hydroxide (NaOH), including experimental methods and results, please visit http://www.nemw.org/GSI/GSI-BS-P-TR-NaOH.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?

Adjust the pH using sodium hydroxide (NaOH) and neutralize by dilution.

What is the proposed application?

In tank treatment of unpumpable residual ballast water and sediments in ships in the "NOBOB" (i.e. no ballast on board) condition, followed by dilution of 1:100 or 1:1000 prior to discharge.

What is the proposed application dose, if any?

NaOH in a concentration sufficient to raise pH to 11.5 -12.5. The doses tested by GSI were NaOH sufficient to raise pH to 11.5, 12.0, and 12.5 in the various water qualities.

RELEVANT CHALLENGE CONDITIONS

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

Dissolved Organic Carbon (DOC) ☐ Light ☐ Temperature ☐ Sediment ☑

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

Dissolved Organic Carbon (DOC) ☐ Light ☐ Temperature ☐ Sediment ☐

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

Dissolved Organic Carbon (DOC) ☑ Light ☑ Temperature ☑ Sediment ☐

GSI DOSE EFFECTIVENESS FINDINGS FOR NaOH

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

Observation times and lowest pH level (11.5, 12.0, or 12.5) at which there was less than 1 % survival of each test species under the most rigorous environmental conditions tested.

Major Taxonomic Group	Species	Less Than 1 % Survival		
		4 Hours	24 Hours	48 Hours
Algae	*Selenastrum sp.*	—	—	✓ (pH = 12.5)
Zooplankton	*Daphnia magna*	✓ (pH 11.5)	✓ (pH 11.5)	✓ (pH 11.5)
Zooplankton	*Eucyclops sp.*	✓ (pH 11.5)	✓ (pH 11.5)	✓ (pH 11.5)
Zooplankton	*Branchionus calyciflorus*	✓ (pH 11.5)	✓ (pH 11.5)	✓ (pH 11.5)
Zooplankton	*B. calyciflorus cysts*[1]	**NA**[2]	**NA**[2]	✓ (pH 12.5)
Insect	*Chironomus dilutus*	**NA**[3]	**NA**[3]	✓ (pH 12.5)
Annelid	*Lumbriculus variegatus*	**NA**[3]	**NA**[3]	✓ (pH 11.5)

— Greater than 1 % survival.

[1] Measured in terms of percent of cysts hatched.

[2] No observations made because cysts cannot be expected to hatch before 24-48 hours.

[3] No interim observations made because assessments are destructive of sample.

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

The zooplankton and annelid worm were most vulnerable to the pH levels tested; the green alga tested was the most resistant.

Other observations related to dose effectiveness tests of this treatment.

Sediment material in the water resulted in greater buffering capacity and the need to add more NaOH to achieve the proposed pH levels. Thus, treatment in the context of heavy sediment loads would require more NaOH to achieve desired pH levels.

GSI DEGRADATION AND RESIDUAL TOXICITY FINDINGS FOR NaOH

How long did it take for the pH that achieved 99 % mortality for <u>all test species</u> to return to an acceptable range (pH 7 to 9)?

Undiluted treated water samples did not return to an acceptable pH within the 48 hour test period. When diluted 1:100, all samples fell within the acceptable range within 48 hours. When diluted 1:1000, all samples returned to a pH within the acceptable range immediately.

Did treated water that diluted according to the proposed treatment still have acute toxicity? If so, what types of organisms were sensitive to the toxicity?

There was no acute toxicity observed following a dilution of 1:100 and 1:1000.

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

Not applicable.

Other observations related to residual toxicity.

If a method could be devised to return treated water to an acceptable pH without dilution, this method could be a candidate for treating full ballast tanks, as well.

MORE INFORMATION

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

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