United States
Environmental Protection
Agency

Environmental Research
Laboratory
Duluth MN 55804

Research and Development

EPA/600/S3-86/026 June 1986

EPA

Project Summary

Evaluation of Site-Specific Criteria for Copper and Zinc: An Integration of Metal Addition Toxicity, Effluent and Receiving Water Toxicity, and Ecological Survey Data

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Comparative laboratory toxicity tests using daphnids *Ceriodaphnia dubia* and fathead minnows *Pimephales promelas* were conducted to establish and evaluate relationships between the toxicity of domestic and industrial effluents containing copper and zinc, toxicity of the effluents in Naugatuck River, Connecticut receiving water, toxicity of each metal added to the receiving water and a reference water, and receiving water ecological survey data. The relationships were used to determine if site-specific water quality criteria for copper and zinc derived according to U.S. Environmental Protection Agency (U.S. EPA) guidelines were protective of aquatic life under complexed ambient conditions caused by point source effluents.

Acute toxicity values for copper exposed *Ceriodaphnia dubia, Scaphrolebaris* sp., and *Pimephales promelas* were used to calculate mean water effect ratios (e.g., site water LC50 value/reference water LC50) reflective of the difference in the biological availability and/or toxicity of copper between Naugatuck River, Connecticut water and Lake Superior reference water. These ratios were used to modify U.S. EPA ambient aquatic life criteria for copper to site- and station-specific criteria using the indicator procedure of the U.S. EPA site-specific guidelines. A mean water effect ratio of 1.0 was obtained using unpolluted upstream water resulting in a site-specific criterion maximum concentration (CMC) and criterion continuous concentration (CCC) of 8.7 and 6.2 μg/l copper, respectively. Mean water effect ratios of 3.9 to 7.0 reflective of reduced biological availability and/or toxicity of copper were determined for four successive downstream stations which contained copper and other industrial and domestic wastes. The resulting station specific CMC(s) and CCC(s) ranged from 32 to 57 and 22 to 39 μg/l copper, respectively. These copper criteria were compared to effluent contributed ambient copper concentrations and ecological survey data from each downstream station to ascertain impact on aquatic life. It was concluded that the national and site-specific criteria derived for copper would be protective of the rivers aquatic life. This conclusion was based on the observation that a relatively healthy aquatic community existed where the copper criterion was exceeded slightly. Whether or not the station specific criteria were protective could not be determined because these criteria were not exceeded at stations with healthy communities; however, where they were exceeded, impaired aquatic communities were evident.

Generally, *Ceriodaphnia dubia* survival and young production data from receiving water tests and copper addition tests conducted during the week prior to the initiation of the acute toxicity tests used to de-

rive site- and station-specific criteria were also indicative of reduced copper biological availability and/or toxicity in the Naugatuck River at downstream stations.

It could not be determined whether or not criteria for zinc were protective of the Naugatuck River biota.

This Project Summary was developed by EPA's Environmental Research Laboratory, Duluth,MN, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The physical and chemical characteristics of water in a natural system may alter the biological availability and toxicity of materials such as copper and zinc. Guidelines for deriving site-specific water quality criteria for the protection of aquatic life and its uses [1,2] which take these factors into account (hereafter referred to as the site-specific guidelines) have been provided by the U.S. Environmental Protection Agency (U.S. EPA). One guideline approach is to simply test a prescribed number of resident species in site water to meet minimum data requirements from which a site criterion is calculated. Another approach is to test sensitive indicator or surrogate species from the same population in both clean reference water, hereafter referred to as laboratory water, and site water at the same time under similar conditions except for water characteristics. The ratio of the site water toxicity value/ lab water toxicity value is used to modify the national criteria value to a site-specific value. Both of these criteria derivation approaches are based on the assumptions: (1) that differences in the toxicity values of a specific material determined in laboratory water and site water may be attributed to chemical (e.g., complexing ligands) and/or physical (e.g., adsorption) factors that alter the biological availability and/or toxicity of a material and (2) that selected test species directly integrate differences in the biological availability and/or toxicity of the material and provide a direct measure of the capacity of a site water to increase or decrease toxicity values relative to values obtained in laboratory water.

Single chemical criteria address effects of pollutants on aquatic life in the absence of other pollutants in the water column, a condition which seldom occurs. A chemical of interest is usually one component of many components in an effluent which may affect the chemical's biological availability or toxicity. The objective of this research project was to determine if site-specific water quality criteria derived for copper and zinc using the indicator species procedure were protective of aquatic life under complexed ambient conditions caused by point source effluents.

The research objective was approached by conducting comparative aquatic toxicity tests to establish toxicity relationships for the metals of interest between a reference water, a relatively unpolluted upstream river water, downstream waters containing effluents and expected to contain the metals of interest in excess of national water quality criteria, and ecological survey data.

This study on derivation and effectiveness of site-specific criteria was integrated with a larger receiving and effluent water study of Mount et al. [3] designed to investigate the use of laboratory effluent toxicity tests to predict ambient stream toxicity impacts at a multiple discharge site on a medium-size river system. The study area extended from Torrington to Ansonia, Connecticut and encompassed 50 kilometers (30 miles) of the Naugatuck River and included both domestic and industrial waste discharges. The industries are mostly small metal refinishing facilities that discharge wastes into tributaries.

Conclusion

This study demonstrates that numerical water quality criteria for copper, if incorporated in water quality standards or National Pollution Discharge Elimination System permits, could be used to protect Naugatuck River biota from copper toxicity. However, in some of the effluent dilution tests where copper was at relatively low concentration and expected to be nontoxic, effluent toxicity was observed. This toxicity may have been due to combinations of known and unidentified chemicals for which criteria are lacking. In these cases, alternate standards based on effluent toxicity limits such as recommended by the U.S. EPA [4] would be necessary to protect the well-being of the river biota.

References

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2. U.S. Environmental Protection Agency. 1983. Water Quality Standards Handbook. Chapter 4. Guidelines for deriving site-specific water quality criteria. Office of Water Regulations and Standards, Washington, DC 20460.
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4. U.S. Environmental Protection Agency. 1985. Technical support document for water quality-based toxic control. Office of Water, Washington, DC 20460.

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The complete report, entitled "Evaluation of Site-Specific Criteria for Copper and Zinc: An Integration of Metal Addition Toxicity, Effluent and Receiving Water Toxicity, and Ecological Survey Data," (Order No. PB 86-183 928/AS; Cost: $11.95, subject to change) will be available only from:

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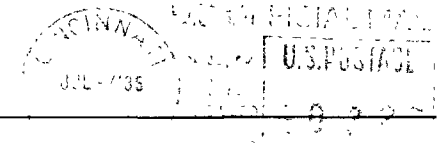

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