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Project Summary

Site-Specific Water Quality Studies of the Straight River, Minnesota: Complex Effluent Toxicity, Zinc Toxicity, and Biological Survey Relationships

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Comparative laboratory toxicity tests using *Ceriodaphnia reticulata* and the fathead minnow *Pimephales promelas* were conducted to establish relationships between the toxicity of a sewage treatment plant effluent containing high concentrations of zinc, toxicity of the effluent in the receiving water, toxicity of zinc added to the receiving water and a reference water, and receiving water biota survey data. Water and biota were sampled under summer (3 times), fall (once) and winter (once) conditions over a one-year period. The relationships were used in evaluating the protectiveness of a site-specific water quality criterion derived for zinc. A strong correlation between the effluents toxicity to daphnids was established, however, toxicity correlation with adverse impact on river biota could not be established.

It was concluded that the effluent did not adversely affect taxa composition and abundance at 2.7 miles (3.2 km) below the discharge to the river. At 2.7 miles the zinc concentrations ranged from <100 to 154 μg/l and averaged 144 μg/l on 3 of 4 sampling dates indicating that a site-specific criterion average concentration of 145 μg/l, approximately 3 times greater than the national average concentration, would be protective of 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/or chemical characteristics of water in a natural system may alter the biological availability and/or toxicity of a material such as zinc. Guidelines for deriving site-specific water quality criteria which take these factors into account have been published by the U.S. Environmental Protection Agency (hereafter referred to as the site-specific guidelines) (U.S. EPA, 1983A). 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 (except for water characteristics) under similar conditions. The ratio of 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. Such 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 chemicals biological availability and/or toxicity.

The objectives of this research project were (1) to evaluate the use of sublethal toxicity test endpoints (effects on survival, growth, and reproduction of selected species) obtained in effluent dilution and receiving water tests for predicting impacts on resident biota; and (2) to determine if site-specific water quality criteria are protective under complexed ambient conditions caused by a point source effluent.

The objectives were approached by conducting aquatic toxicity tests to establish relationships between the toxicity of a sewage plant effluent (STP) containing high concentrations of zinc, toxicity of the effluent in the receiving water, toxicity of zinc added to receiving water and a laboratory water, and biological survey data.

Conclusions

A strong correlation between the effluents toxicity and zinc toxicity was established; however, toxicity correlation with adverse impact on river biota could not be established. The lack of correlation between effluent toxicity to daphnids and biological impact in the river at a sampling station approximately 1 mile (1.6 km) downstream from the STP discharge may have been due to not sampling and testing the effluent and receiving water over a sufficient number of days to get a measure of the exposure duration of the river biota to conditions toxic to the test animals. Often river flow had been higher prior to sampling indicating that susceptible biota may not have time to react to adverse conditions. The higher flow may also have contributed to biota recolonization which may have masked effluent impact.

Under the conditions of this study the distribution of benthic-macroinvertebrates and fish did not appear to be adversely impacted by the STP effluent or its zinc component at a sampling station approximately 2.7 miles (3.2 km) downstream. At this station, zinc concentrations ranged from <100 to 154 µg/l on the 4 dates it was sampled and averaged 144 µg/l on 3 of 4 sampling dates. The total number of benthic-macroinvertebrate taxa found at this station were similar or greater than found at the reference station on the 4 sampling dates. The total number of fish species were similar between these stations on the 2 dates they were sampled. The total number of plankton taxa were markedly different on 1 of the 3 dates they were sampled. This difference could have been due to predation or upstream effluent impacts causing plankton death and/or sedimentation. Nevertheless, if the assumption of the national (U.S. EPA, 1983B) and site-specific guidelines that the protection of site-species all of the time is not necessary because aquatic life can tolerate some stress and occasional adverse effects is taken into consideration, these data indicate that a site-specific criterion average concentration of 145 µg/l, approximately 3 times greater than the national average concentration would be protective of Straight River biota.

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The complete report, entitled "Site-Specific Water Quality Studies of the Straight River, Minnesota: Complex Effluent Toxicity, Zinc Toxicity, and Biological Survey Relationships," (Order No. PB 85-160 703/AS; Cost: $10.00, subject to change) will be available only from:

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