10-1-2002

Technical Bulletins: Biomonitoring for the National Pollution Discharge Elimination System Permit (NPDES)

Steve Wyatt
Municipal Technical Advisory Service, steve.wyatt@tennessee.edu

MTAS
MUNICIPAL TECHNICAL ADVISORY SERVICE

October 2002

BIOMONITORING FOR THE NATIONAL POLLUTION DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT

by
Steve Wyatt, Utility Operations Consultant

Introduction

One requirement of the NPDES permit for a large number of publicly owned treatment works (POTW) is biomonitoring. Test frequency is either quarterly or semi-annually for the life of the permit.

Biomonitoring can be defined loosely as using a living organism to determine the detrimental effects of POTW effluent on the receiving stream. *Ceriodaphnia dubia* (water flea) and *Pimephales promelas* (fathead minnow) are the two species used in the analysis because they represent the aquatic life found in the receiving stream of treated effluent.

During the late 1970s and early 1980s, the EPA began to evaluate biomonitoring as a tool to protect lakes and streams in the United States. The EPA states, "Biological testing of effluents is an important aspect of the water quality-based approach for controlling toxic pollutants." Effluent toxicity data, in conjunction with other data, can be used to check compliance with state water quality standards and set permit limits. Permits began to require biomonitoring in the mid 1980s.

The term "whole effluent toxicity" (WET) refers to looking at effluent as a single component. Thus, the test cannot identify the specific contaminant that produces toxicity. Toxicity actually may be caused by a mixture of contaminants, which separately do not cause toxicity. The individual contaminants could be within NPDES permit limits and still produce toxicity.

Biomonitoring Requirements

The Tennessee Department of Environment and Conservation Division of Water Pollution Control (TDECWPC) evaluates all dischargers for reasonable potential to exceed "no toxics in toxic amounts." The division has determined that for POTWs with stream dilutions of less than 500 to one, any of the following conditions demonstrates reasonable potential to exceed this threshold:

- Toxicity is suspected or demonstrated;
- A pretreatment program is required;
- The design capacity of the facility is greater than 1.0 mgd (million gallons per day).

Meeting one of these criteria requires the POTW to have biomonitoring as a requirement on its NPDES permit.

Methodology to Set Limits

NPDES permits in the past used no observable effect concentration (NOEC) to measure chronic toxicity and a 96-hour lethal concentration 50 (LC50) to measure acute toxicity. TDECWPC is no longer using these two parameters to measure toxicity.

Permits now are being issued with an inhibition concentration of 25 percent (IC25). IC25 represents a 25 percent reduction in survival, reproduction or growth of the test organisms from a control group. The IC25 calculation is based on the design flow of the POTW and the seven-day low flow over 10 years in the receiving stream (7Q10).

The formula is:
IC25 = design flow / (7Q10 + design flow) X 100

Example:
The low flow for the receiving stream (7Q10) is 23 mgd. The design flow for the POTW is 4 mgd.Therefore:

IC25 = 4 / (23 + 4) X 100
IC25 = 14.8 percent

The POTW demonstrates toxicity if the test value is less than or equal to the calculated value. This is a violation of the NPDES permit.

The permit would specify a serial dilution for the laboratory to use. The percentage of effluents used in the example would be 59.2 percent, 29.6 percent, 14.8 percent, 7.4 percent, 3.7 percent and a control with zero percent effluent. These dilutions represent a multiplier from the calculated IC25. The 59.2 percent value is four times 14.8. The 29.6 value is two times 14.8, 7.4 percent is half of 14.8 percent, and 3.7 percent is one-fourth of 14.8 percent.

Toxicity is demonstrated if there is a statistically significant difference between any dilution and the control set. The difference can be in any of the three parameters: survival, reproduction or growth. In our example, the effluent would fail if toxicity appears in the 14.8, 7.4 or 3.7 percent dilutions.

What Happens if Your POTW Fails the Test?

If the POTW has a test failure, the permittee must start a follow-up test within two weeks and submit the results from the follow-up within 30 days from obtaining the WET results. The follow-up test will not negate the initial failed test, and the failure of a follow-up test will constitute a separate permit violation.

If the POTW has two consecutive test failures or three test failures within a 12-month period for the same outfall, the permittee must initiate a toxicity identification evaluation/toxicity reduction evaluation (TIE/TRE) study within 30 days and so notify the division by letter.

During the TIE/TRE, the POTW will continue biomonitoring every three months until it can demonstrate compliance. Two consecutive tests from the same outfall that have a value larger than the calculated value are required to demonstrate compliance. The POTW has two years from initiation of the TIE/TRE to reduce toxicity at the outfall.

How Can the Operator Determine Why the Test Failed?

It is very difficult to determine why a test failed. Even if a plant performs an extensive TIE/TRE, the cause of a failure may never be known. Following are some suggestions for how the operator can determine a cause:

1. Speak to laboratory staff who performed the test. See if they have any ideas about why the failure occurred. Ask if any other clients failed the test at the same time your test was run.
2. Review lab and operational records to see what was different at the plant when the test failed compared to previous tests that passed.
3. Review industrial pretreatment analysis for the time period.
4. Interview staff to review sampling and handling of the samples.

5. When you rerun the test, consider splitting the sample and having it performed by two different laboratories.

Contaminants in the effluent may be in acceptable NPDES limits but still cause toxic reactions to the fathead minnow or water flea. Suspended solids can cause problems in the gills, ammonia at low levels can be toxic, chlorine or dechlorinating compounds can be toxic, and the list continues. Toxicity could even be synergistic in that two or more compounds found in acceptable levels in the effluent could cause toxic conditions in combination.

How the IC25 Works

The IC25 usually requires a 3-Brood *Ceriodaphnia dubia* Survival and Reproduction Test and a 7-Day Fathead Minnow Larva Survival and Growth Test on samples from the final effluent from the POTW. All tests are conducted using a minimum of three 24-hour flow-proportionate composite samples of the final effluent collected on days one, three and five.

As with any such procedure there is the possibility for an invalid test. TDECWPC has specific language on the methodology that must be used, as well as what a POTW must do if there is an invalid test. An invalid test is defined thus: "If, in any control more than 20 percent of the test organisms die in seven days, the test (control and effluent) is considered invalid, and the test shall be repeated within two weeks. Furthermore, if the results do not meet the acceptability criteria of Section 4.9.1, EPA/600/4-92/002, that test shall be repeated. Any test initiated but terminated before completion must also be reported along with a complete explanation for the termination."

The test involves both species of organisms, which are placed into five serial dilutions with a control set of organisms. Over the seven-day test period, the water in each dilution and control is changed with aliquots from the three composite samples. Light and temperature conditions are controlled to meet the requirements of the test, and water quality is recorded daily. At the end of seven days the control organisms are used to measure the inhibition of the effluent against the organisms in the serial dilutions of POTW effluent. The permit will specify the dilution sequence that the laboratory must use.

The 3-Brood *Ceriodaphnia dubia* Survival and Reproduction Test consists of a *Ceriodaphnia dubia* control group, which will give birth to three broods (sets of offspring) over seven days. The number of these offspring is recorded daily, as is the number of offspring in the dilutions. When there is a significant statistical difference between the number of offspring, toxicity has occurred. Any deaths in the water flea groups will be recorded. A significant statistical difference in the number of deaths in the control group versus the organisms in dilution also indicates toxicity.

The 7-Day Fathead Minnow Larva Survival and Growth Test will have a control set of minnows that will gain weight over a seven-day period. These control minnows will be weighed at the end of the seven days. If there is a significant difference in the weight gain of the control group versus organisms in the effluent dilution, then toxicity has occurred. All minnow deaths are recorded. If there is a significant statistical difference in the number of deaths in the control group versus the organisms in the dilution would also indicate toxicity.

References

1. *Whole Effluent Toxicity: Guidelines Establishing Test Procedures for the Analysis of Pollutants (RIN-2040-AC54),* U.S. Environmental Protection Agency. 40 CFR Part 136; WH-FRL-5308-7
2. *Short Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Water to Freshwater Organisms, Third Edition (EPA/600/4-91/002)*. U.S. Environmental Protection Agency.
3. *Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms. Fourth Edition (EPA/600/4-90/027F)*. U.S. Environmental Protection Agency.
4. Tennessee Department of Environment and Conservation Division of Water Pollution Control, general permit language.

For More Information

Please contact your MTAS Utility Operations Consultant. Or, call the **MTAS Answer Line** to receive quick answers to short questions: **(888) 667-MTAS** (6827). You also may visit our Web site at **www.mtas.utk.edu**.

The Municipal Technical Advisory Service (MTAS) is a statewide agency of The University of Tennessee's Institute for Public Service. MTAS operates in cooperation with the Tennessee Municipal League to provide technical assistance services to officials of Tennessee's incorporated municipalities. Assistance is offered in areas such as accounting, administration, finance, public works, ordinance codification, and wastewater management.

MTAS *Technical Bulletins* are information briefs that provide a timely review of topics of interest to Tennessee municipal officials. *Bulletins* are free to Tennessee local, state, and federal government officials and are available to others for $2 each.

MTAS OFFICES

Knoxville (Headquarters)
Phone: (865) 974-0411
Fax: (865) 974-0423

Johnson City
Phone: (423) 854-9882
Fax: (423) 854-9223

Nashville
Phone: (615) 532-6827
Fax (615) 532-4963

Jackson
Phone: (731) 423-3710
Fax: (731) 425-4771

Martin
Phone: (731) 587-7055
Fax: (731) 587-7059

E14-1050-000-054-03