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Technical Bulletins: Biomonitoring for the National Pollution Discharge Elimination System Permit (NPDES) (2008)

Steve Wyatt

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

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May 15, 2008

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

Steve Wyatt, Utility Operations Consultant

INTRODUCTION

Biomonitoring testing is listed as a requirement on the NPDES permit for a large number of publicly owned treatment works (POTW). The test is required either quarterly, semiannually or annually for the life of the permit.

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

During the late 1970s and early 1980s, the Environmental Protection Agency (EPA) began to evaluate biomonitoring as a tool to protect the lakes and streams of the United States. Permits began to have biomonitoring as a requirement in the mid-1980s. EPA's policy 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.

The term "whole effluent toxicity" (WET) describes looking at an effluent as one component. Thus the test cannot identify the specific contaminant that is producing the toxicity. Toxicity may actually be caused by a mixture of contaminants, which separately do not cause toxicity. These contaminants could be within NPDES permit limits and still exhibit toxicity.

WHEN WILL BIOMONITORING BE REQUIRED?

The Tennessee Department of Environment and Conservation Division of Water Pollution Control (TDEC-WPC) evaluates all dischargers for reasonable potential to exceed the standard of "no toxics in toxic amounts." The division has determined that for a POTW with stream dilutions of less than 500 to 1, any of the following conditions demonstrates reasonable potential to exceed no toxics in toxic amounts:

- Toxicity is suspected or demonstrated;
- A pre-treatment program is required; or
- The design capacity of the facility is greater than 1.0 MGD.

Meeting one of the above criteria will require a POTW to have biomonitoring listed as a requirement on its NPDES permit.

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METHODOLOGY TO SET LIMITS

NPDES permits in the past used a “no observable effect concentration” (NOEC) to measure chronic toxicity and a 96-hour lethal concentration 50 (LC50) to measure acute toxicity. TDEC-WPC no longer uses NOEC to measure toxicity.

Permits are now being issued with an inhibition concentration 25% (IC25). IC25 represents a 25 percent reduction of survival, reproduction and growth of the test organisms from a control group of test organisms. IC25 is a calculation 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:

$$IC25 = \text{design flow} / (7Q10 + \text{design flow}) * 100.$$

Example:

The low flow for the receiving stream (7Q10) is 23 MGD. The design flow for the POTW is 4 MGD.

$$IC25 = 4 / (23 + 4) * 100$$

$$IC25 = 14.8\%$$

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

In the above example the permit would specify a serial dilution that the laboratory would use. The percentages of effluent used in the example would be 59.2, 29.6, 14.8,

7.4, 3.7 and a control with 0 percent effluent. These dilutions represent a multiplier from the calculated IC 25. Thus, 4 times 14.8% = 59.2%; 2 times 14.8% = 29.6%; 7.4% is one-half of 14.8%; and 3.7% is one-fourth of 14.8%.

Toxicity is demonstrated if there is a statistical significant difference in any dilution from the control set. The difference can be in any of the three parameters: survival reproduction, or growth. **In the example, the effluent fails if toxicity appears in the 14.8% or 7.4% or 3.7% dilutions.**

Occasionally, a test will have abnormal results. If this occurs, TDEC will require the POTW to redo the sampling and test.

WHAT HAPPENS IF THE TEST FAILS?

If the POTW has a test failure, the permittee must start a follow-up test within two weeks, and submit the results of that test within 30 days from obtaining the WET results. The follow-up test will not negate the initial failed test. In addition, 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 notify the division by letter. During the TIE/TRE, the POTW will continue

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biomonitoring every three months until compliance is demonstrated. Demonstrated compliance is two consecutive tests from the same outfall that have a value larger than the calculated value. The POTW has two years from the initiation of the TIE/TRE to reduce toxicity at the outfall.

THINGS OPERATORS CAN CHECK TO 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 determined. Listed below are some suggestions on what an operator can do to determine a cause:

1. Talk to the laboratory that performed the test. See if they have any ideas about what occurred. Ask if anyone else failed the test at the same time your test was being run.
2. Review lab and operational records to see what was different at the plant when the test failed versus previous tests that did not fail.
3. Review industrial pre-treatment analysis for the time period.
4. Interview staff and review sampling and handling of the samples.
5. When repeating the test, consider splitting the sample and having analysis performed by two separate laboratories.

Contaminates in the effluent may be within 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 de-chlorinating compounds can be toxic; and the list goes on. The toxicity could even be synergistic in nature in that two or more compounds found in acceptable levels in the effluent could cause toxic conditions when mixed.

TEST

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 will be 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 testing there is the possibility for an invalid test. TDEC-WPC has specific language on the methodology that must be used as well as what a POTW must do if there is an invalid test. "If, in any control more than 20% 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 that are placed into five serial dilutions with

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

The 3-Brood *Ceriodaphnia dubia* Survival and Reproduction Test consists of a *Ceriodaphnia dubia* control group that would give birth to three broods (sets of offspring) over the course of seven days. The number of offspring is recorded daily. A series of effluent dilutions have water fleas that also will produce the three broods. The number of offspring produced in the dilutions is counted. When there is a significant statistical difference between the number of offspring produced in the control group and the number of offspring produced in the dilutions, toxicity has occurred. Deaths among the groups are calculated in the same manner.

The 7-Day Fathead Minnow Larva Survival and Growth Test has a control set of minnows that will gain weight over a seven-day period. These control minnows are weighed at the end of the seven days. If there is a significant difference in the weight gain of the control group versus the organisms in the effluent dilution, toxicity has occurred.

Any deaths of the minnows are recorded. A significant statistical difference in the number of deaths in the control group versus the organisms in the dilution indicates toxicity.

LC50

A few POTWs have LC50 as a biomonitoring requirement rather than IC25.

LC50 is a 48-hour acute toxicity test using the same two species used in the IC25. The measured endpoint for toxicity will be the concentration causing 50 percent lethality (LC50) of the test organisms. The LC50 shall be determined based on a 50 percent lethality compared to the controls and as derived from linear interpolation.

The test shall have five serial dilutions of the effluent and a control. All tests will be conducted using four separate grab samples collected at evenly spaced (six-hour) intervals over a 24-hour period. If more than 10 percent of the control test organisms die in 48 hours, the test (control and effluent) is considered invalid, and the test shall be repeated within two weeks.

REFERENCES

1. Environmental Protection Agency, RIN-2040-AC54; *Whole Effluent Toxicity: Guidelines Establishing Test Procedures for the Analysis of Pollutants*. 40 CFR Part 136; WH-FRL-5308-7.

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2. *Short Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Water to Freshwater Organisms*. Third Edition; EPA/600/4-91/002.
3. *Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms*. Fourth Edition; EPA/600/4-90/027F.
4. Tennessee Department of Environment and Conservation Division of Water Pollution Control, general permit language.

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