

Stepping stones: A retrospective on the developments and applications of toxicity testing to effluents and sediments and the importance of SETAC

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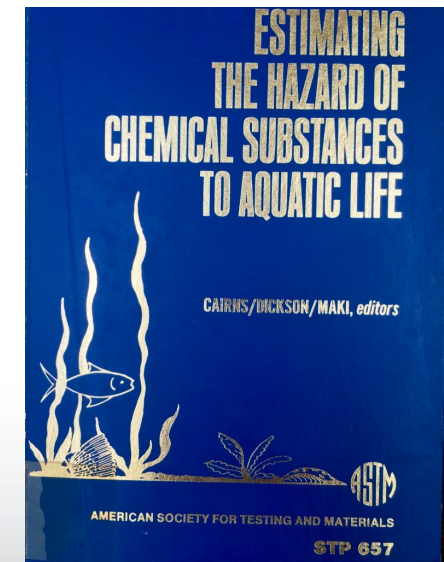
USEPA, Office of Research and Development
The Center for Computational Toxicology and Exposure
Great Lakes Toxicology and Ecology Division
Duluth, MN

SESSION: Oh, the Changes I've Seen Over the Past 30 Years
SETAC 40th Annual Meeting
Toronto, Ontario, CAN

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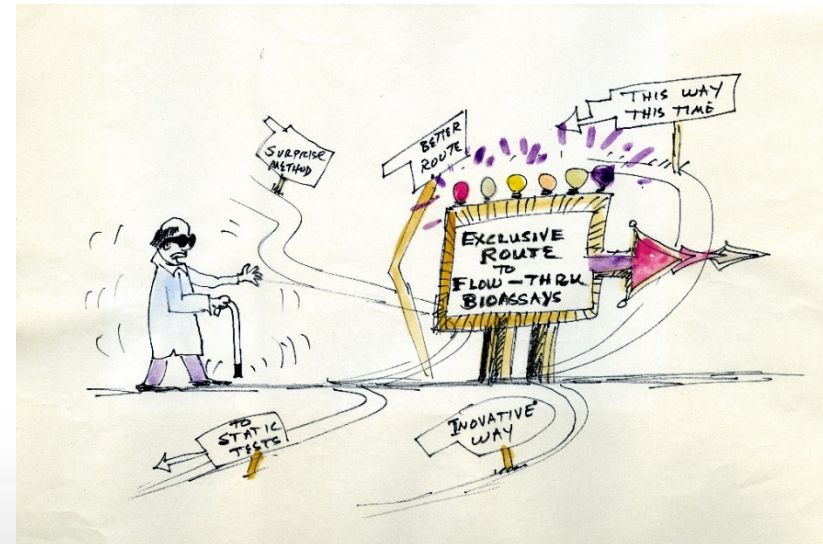
Limits to Using Chemical-Specific Criteria

- Impractical to generate sufficient data for all chemicals (100,000+)
- Criteria may not account for all the factors that affect the bioavailability or toxicity of chemicals
- Criteria do not consider the aggregate effect of all chemicals present
- WET testing provides a direct measure of toxicity along with the protection from chemical-specific criteria



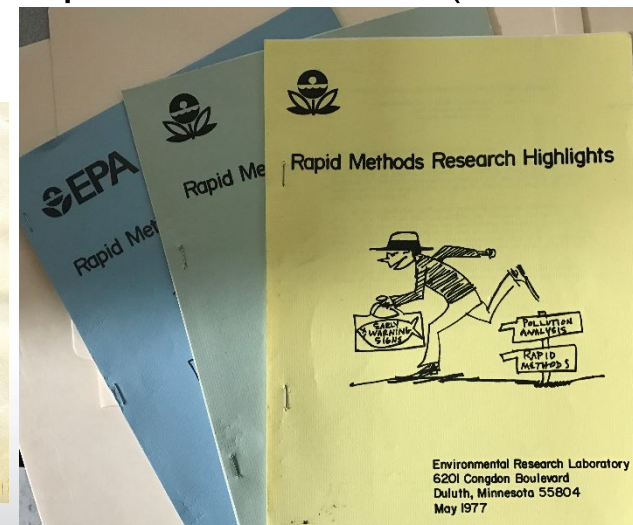
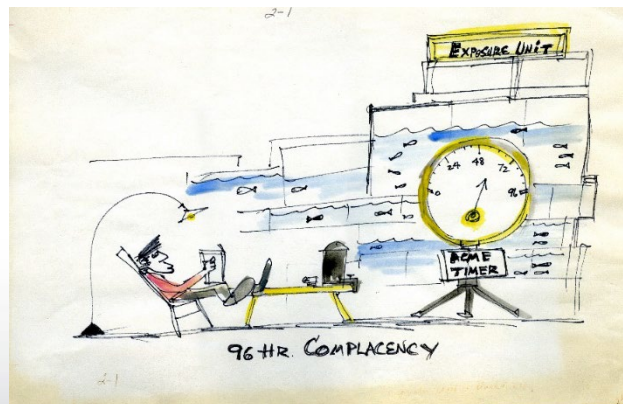
Whole Effluent Toxicity (WET) Tests

- 1st WET tests in 1976 for regulatory purposes
 - Quarterly on-site flow-through acute tests with bluegill sunfish.
 - Violation of permit
- Acute tests (≤ 96 -h) were the workhorse in 70's
 - Static, or static-renewal
 - Flow-through would be on-site
 - .



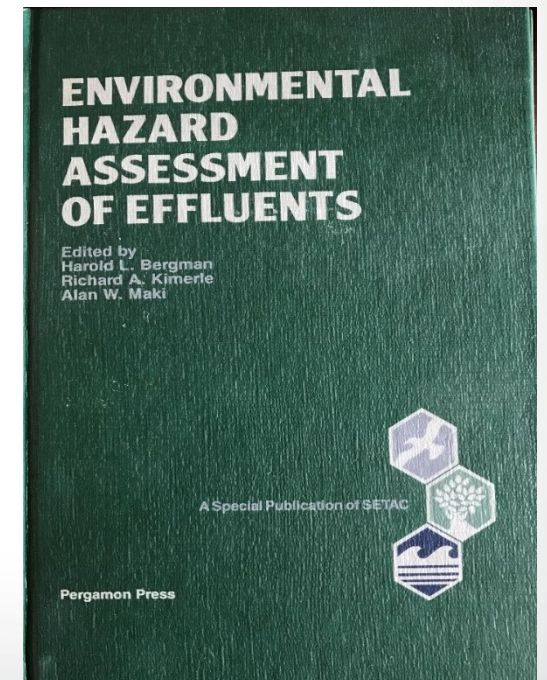
Research for Cost-Effective, Short-term Tests to Predict Chronic Toxicity

- In May of 77, scientists started communicating with “Rapid Methods Research Highlights”
 - Govt, Academia, Industry contributions
- And ORD-Duluth in late ‘79, began method development on a daphnid chronic test for freshwater
 - “New test species” for short-term chronic test, i.e., *Ceriodaphnia dubia* 7-d (3 brood) test and the companion fathead minnow test (7-d)



Hazard Assessment of Effluents Workshop

- 1982 workshop on the scientific and appropriateness of using WET tests in effluent hazard assessment schemes
- A critical review of methods used for biological effects testing, exposure assessment, and overall hazard assessment of effluent and complex mixtures.



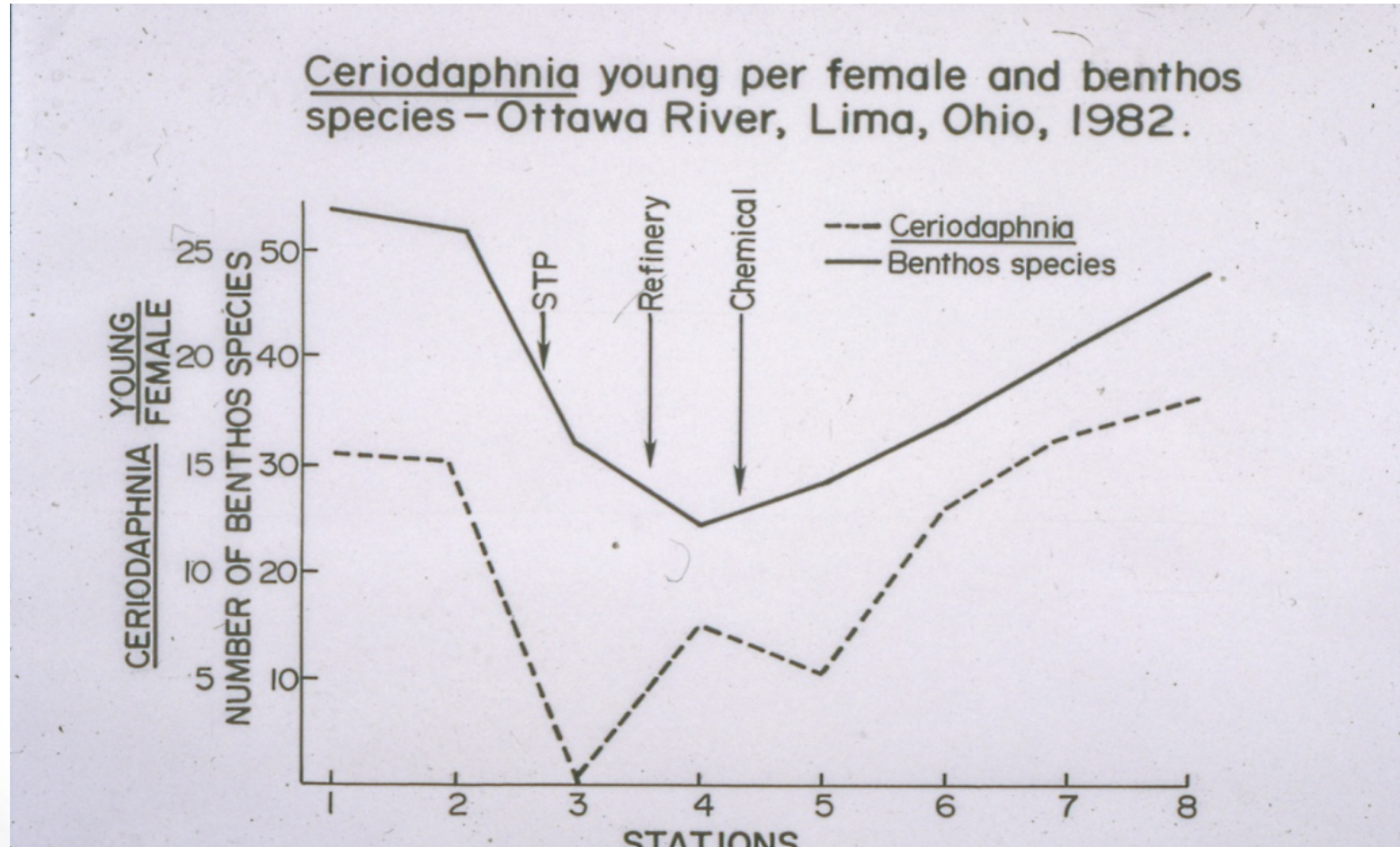
Complex Effluent Testing Program in ORD

Field Studies to Validate the Use of WET testing



- Starting in 1981, as ORD developed methods, applied the ‘new’ sublethal toxicity tests for 8 site studies of discharger into streams, from small to large.
- Research effort where WET testing was used to evaluate ambient toxicity and ambient waters toxicity testing and instream community assessment to “validate” concept of using toxicity tests as an indicator of instream effect.

Compared the results from effluent toxicity, ambient toxicity, and field assessment



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Research and Development

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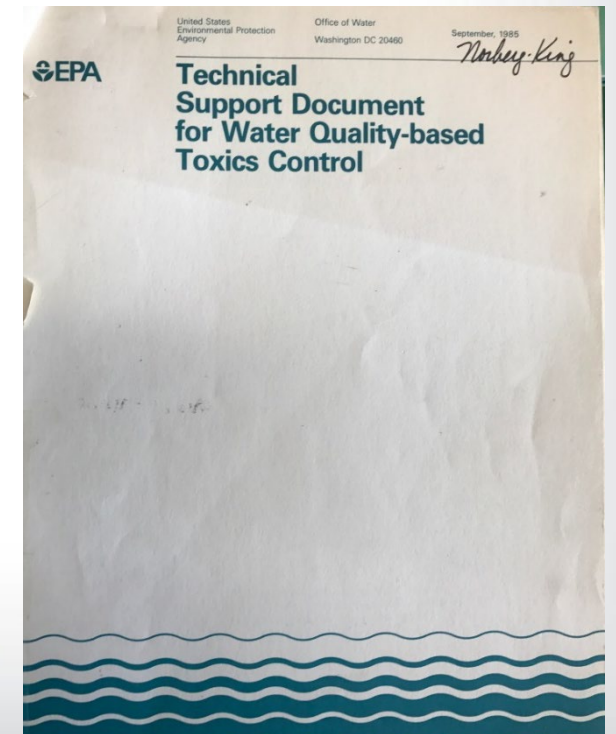
EPA-600/3-84-08D
August 1984

**Effluent and
Ambient Toxicity
Testing and
Instream
Community
Response on the
Ottawa River,
Lima, Ohio**

For the Lima, OH study, the laboratory Ceriodaphnia toxicity results correlated well with the number of benthic species

Integrated Approach to Water Quality-based Toxics Control

- Recognition that an effluent can “pass” the chemical limits and still be toxic.
- EPA implemented a National Policy where the “discharge of toxic pollutants in toxic amounts be prohibited”.
- Directly implements States’ numeric or narrative criteria:
 - “no toxics in toxic amounts”.
- Components of the WQ-Based Toxics Control
 - chemical specific controls (129 priority pollutants)
 - whole effluent toxicity controls
 - biological criteria/bioassessments

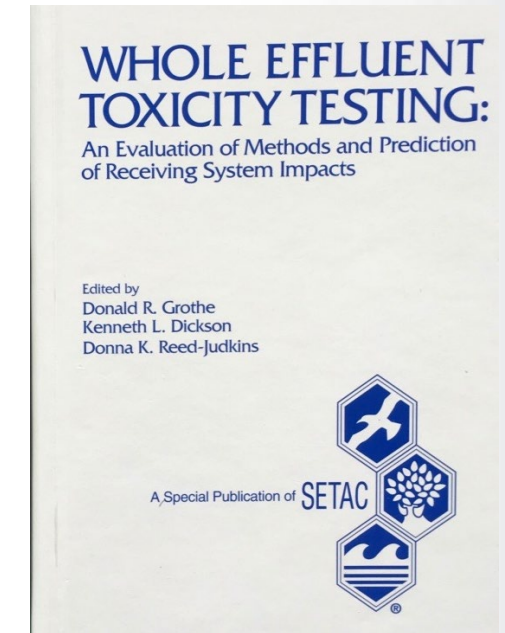


WET Testing for Aquatic Life Protection

- With the “toxicity based’ approach the aggregate toxicity of all constituents in an effluent are evaluated through biological testing (WET)
- EPA developed test methods and standard effluent test methods for both acute and short-term chronic tests
 - Concept that the species are surrogates
 - Using trophic level approach for sensitivity evaluation
 - Fish, invertebrate, plant

WET: An Evaluation of Methods and Prediction of Receiving Systems Impact

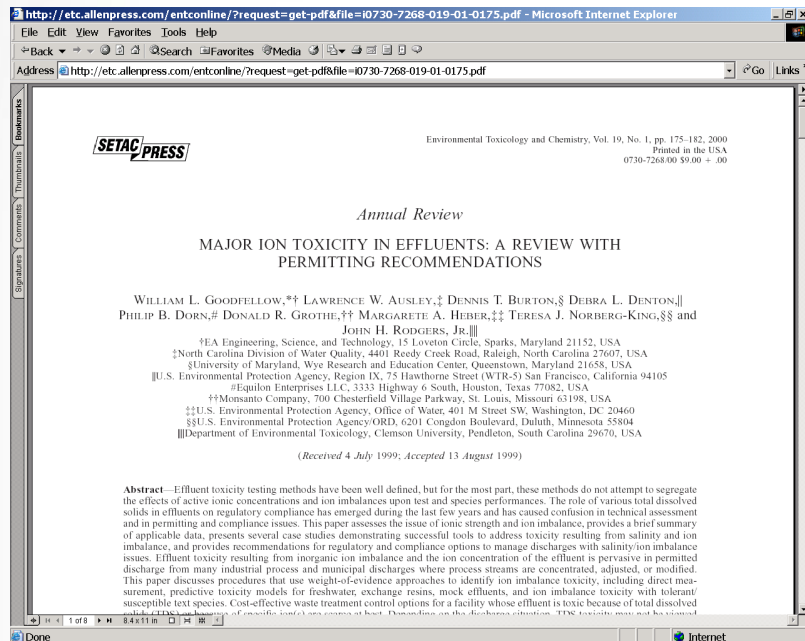
- As WET approach was implemented, controversy arose from the regulated community regarding the scientific validity of the WET approach.
- Pellston workshop in 1995
 - Fine-tuning at the margins of scientifically sound program, focusing more on data interpretation than the WET testing techniques.
 - Interplay between science and policy always existed in the WET program (Grothe et al)



Actions Emerging from the Workshop

- Listening sessions for technical needs on issues related WET testing for permitting.
- In 1996, SETAC's Research Foundation received a cooperative agreement to develop technical support and training for WET:
 - SETAC Whole Effluent Toxicity (WET) Effluent Advisory Panels (EAP's)
 - Provide expert scientific advice about the technical aspects of WET testing of effluent and surface water toxicity testing, characterizing, and identifying sources of toxicity in complex effluents.
 - Using the SETAC tripartite formula, scientists from academia, government, and private sector came together to develop consensus opinion and advice under the SETAC umbrella to address key technical issues (not policy)

Technical Products from the Effluent Advisory Panels (EAP)



SETAC Whole Effluent Toxicity Experts Advisory Panels - Microsoft Internet Explorer

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Address <http://www.setac.org/wetindex.html>



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Whole Effluent Toxicity Expert Advisory Panels

What are the SETAC Whole Effluent Toxicity Expert Advisory Panels (WET EAP)?


Expert Advisory Panels	FAQs
1998 Accomplishments	WET Publications
1999 Accomplishments	EPA WET links
2000 Accomplishments	WET Contacts
WET Training	
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Questions, comments, and requests should be e-mailed to:



this issue:

Whole Effluent Toxicity Testing: Ion Imbalance



SETACTIP*

***technical issue paper**

Purpose: SETAC is a professional society with worldwide membership from academia, government, business, and nongovernmental organizations. TIPs provide a credible and balanced scientific discussion of important environmental issues.

What is Whole Effluent Toxicity (WET) testing?

Whole Effluent Toxicity (WET) testing is an important component of the U.S. Environmental Protection Agency's (USEPA) integrated approach for assessing the potential for toxicity to the nation's waters. WET testing is used in USEPA's National Pollutant Discharge Elimination System (NPDES) to regulate industrial and municipal point source wastewater discharges. However, most non-point source discharges are not regulated by USEPA under the NPDES permit system.

The primary objective of WET testing is to ensure that treated effluent released from industrial and municipal facilities into the nation's waters does not cause unacceptable levels of in-stream toxicity to aquatic life. To determine whether an effluent has the potential to be toxic, WET tests are performed on various aquatic test species. Depending on the regulatory goal of the test, the test may be short term (acute) or long term (chronic). Acute tests are usually performed to determine the survival of organisms exposed to various concentrations of effluent. Chronic tests are generally conducted to assess survival, growth, and reproduction of organisms.

organic compounds. Recently, it has been established that many other elements and compounds, including several ions commonly found in aquatic ecosystems, can also be toxic to aquatic organisms when present in concentrations above or below biologically tolerable levels. The issue of ion imbalance has caused confusion in technical assessments of effluents and in permitting or compliance because dischargers and regulators often are not aware of the problem and/or it is difficult to identify ion imbalance through traditional toxicity testing procedures.


What is an ion?

An ion is an atom or a group of atoms whose negative or positive electric charge results from having lost or gained one or more electrons. When an acid, base, or salt dissolves in water, some of its atoms or elements separate into positive and negative ions. Cations are positive ions formed by the loss of electrons; anions are negative ions formed by the gain of electrons. The number of electrons lost or gained is denoted by a positive sign for cations (e.g., Mg^{2+} for magnesium) or a minus sign for an anion (e.g., F^{-} for fluoride).

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this issue:

Whole Effluent Toxicity Testing



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What is Whole Effluent Toxicity (WET) testing?

Whole Effluent Toxicity (WET) testing is an important component of the U.S. Environmental Protection Agency's (USEPA) integrated approach for detecting and addressing toxicity in surface waters. The National Pollutant Discharge Elimination System (NPDES) permit program, authorized by the Clean Water Act, controls water pollution by regulating point source discharges into waters of the United States. Point sources are discrete structures such as pipes or man-made ditches. The wastewater discharges from point sources are commonly called "effluents." Facilities must obtain permits for direct discharges to surface waters and, in many cases, for storm sewer systems. A permit specifies the conditions that must be met to discharge. Permits often include WET tests as a monitoring requirement and sometimes for compliance determination.

"WET" is a term used to describe the adverse effects or toxicity to a population of aquatic organisms caused by exposure to an effluent. This toxicity can be experimentally determined in the laboratory by exposing sensitive organisms (usually surrogate organisms representative of those found in the environment) to effluents using WET tests. WET testing may show that chemicals known to be toxic to aquatic organisms are present in effluents, and/or that the effluent is toxic to aquatic organisms.

amounts of pollutants to surface waters. The standardized procedures of WET tests allow one to determine the actual environmental exposure of aquatic life to an effluent or ambient water without knowledge of the chemical, physical, and biological characteristics of that discharge or ambient water.

WET tests can be performed on a variety of commonly used test species under a variety of exposure periods and dilution regimes. Acute tests are conducted for a relatively short period and usually focus on how well an organism survives. Chronic tests are conducted for longer periods relative to certain organisms' life cycle or during a very sensitive life stage to evaluate survival, growth, and/or reproduction. Tests may be conducted on an undiluted sample to answer the question, "Is this sample toxic to this test species?" Often, testing includes the undiluted sample along with a series of dilutions of the sample to answer the question, "How toxic is this sample to this test organism?"

Some regulatory approaches focus on controlling toxic amounts of individual chemicals known to be present in the effluent. In contrast, WET testing actually measures the potential toxicity of all chemicals in a solution. Furthermore, WET testing may show that chemicals known to be toxic to aquatic organisms are present in effluents, and/or that the effluent is toxic to aquatic organisms.

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Address <http://www.setac.org/wetFAQs.html>

FREQUENTLY ASKED QUESTIONS ???

This information is provided in response to questions about whole effluent toxicity (WET). It was generated by the WET Expert Advisory Panels Steering Committee, all volunteers and all members of the Society of Environmental Toxicology and Chemistry (SETAC). Each person is considered an expert in some aspect of WET, and the information provided here represents the consensus of the Committee's collective expertise at the time this document was written (Feb., 1999).

This information is intended to stimulate further discussion about WET, WET-related research, and the science underlying WET. The information is not to be construed as representing an official position of SETAC, the SETAC Foundation for Environmental Education, or the U.S. Environmental Protection Agency. [This information was produced under the WET Cooperative Agreement No. CX 824845-01-0.]

Is it possible that pathogenic organisms can influence the results of whole effluent toxicity tests?

If wastewater treatment plant effluent is discharged to a saltwater or brackish water body, should the effluent be treated to remove salt before discharge?

Web Pages with Frequently Asked Questions (FAQ's) (see link at SETAC's website). FAQ's from questions submitted to the EAP and consensus committee FAQ response.

Training Sponsored by SETAC

1997-2001

- A WET Tale: Toxicity of Complex Effluents
 - 2-d day course on the whole effluent program and methods used for assessing toxicity
- Toxicity Reduction Evaluation/Toxicity Identification Evaluation TIE Training
 - Concepts of TRE/TIEs to provide a basic understanding of the tools used in the TRE strategy.
- Taming the Wild, Wild WET
 - Analysis and Interpretation of Toxicity Tests: Basic overview of WET statistical analysis, common difficulties in analysis, effective experimental design and analysis, and common questions related to WET data interpretation.
- Hands-On WET Training
 - understanding of test methods for typical NPDES test procedures including the Ceriodaphnia dubia test.

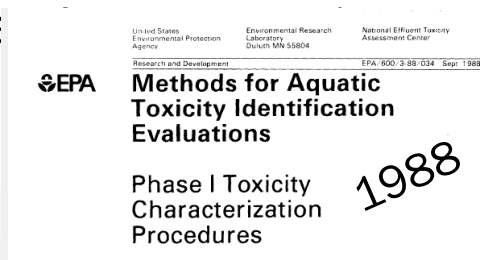
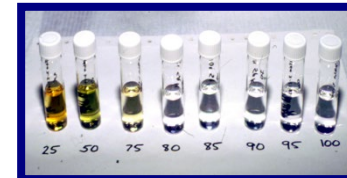
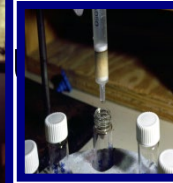
SETAC Educational Training Courses: WET Training Courses



From 1997 to 2002, over 1,100 people attended SETAC training

Methods for Toxicity Identification Evaluations (TIEs)

- As we observed toxicity in these site studies, we began trying to figure out what was causing it.
- At EPA-Duluth, we developed methods to
 - characterize (Phase I), Identify (Phase II), confirm (Phase III), chemical responsible for toxicity
- TIEs use toxicity testing and chemical manipulations in a logical, iterative process to identify cause of toxicity.
 - Applicable to effluents, ambient waters, and sediments (bulk and individual components)



Advantages of Identifying Toxicant

- Much broader range of control options available
 - treatment
 - source control
 - process modification
 - product substitution
- Much greater confidence that remedial action will control problem
- Ability to monitor future compliance easily

Training Agreement With SETAC Foundation

- In 1996, SETAC's Research Foundation received a cooperative agreement to fund technical support activities for WET:
 - SETAC Whole Effluent Toxicity (WET) Effluent Advisory Panels (EAP's)
 - Provide expert scientific advice about the technical aspects of WET testing of effluent and surface water toxicity testing, characterizing, and identifying sources of toxicity in complex effluents
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Publications of the WET Effluent Advisory Panel on TRE/TIE's

- The WET EAP, whether directly or indirectly was very successful in publishing a variety of materials in several formats including books, formal journal articles, white papers and FAQs.

The WET EAP Steering Committee invited the following individuals to provide their experience and expertise:

Academia

Steve Klaine, Clemson University
Tom Waller, University of North Texas

Business

Ray Arnold, Exxon Biomedical Sciences
Bill Goodfellow, EA Engineering, Science, and Technology
Russ Hockett, ENSR Consulting and Engineering
Don Mount, ASci Corporation

Government

Larry Ausley, North Carolina Division of Water Quality
Debra Denton, USEPA
Margarete Heber, USEPA
Teresa Norberg-King, USEPA
Peter Ruffier, City of Eugene, Oregon

The Panel met in Sparks, Maryland, 11 to 13 February 1998.



Application of TIEs/TREs to Whole Effluent Toxicity: Principles and Guidance

weteap.larryausley.com/

A report of the WET Expert Advisory Panel on TIE/TRE
Society of Environmental Toxicology and Chemistry (SETAC)

and

SETAC Foundation for Environmental Education
1010 North 12th Avenue
Pensacola, FL 32501-3367, USA

First printing June 1998

This report was produced under the SETAC Foundation's WET Cooperative Agreement with U.S. Environmental Protection Agency, No. CX 824845-01-0.

August 1998

FOREWORD

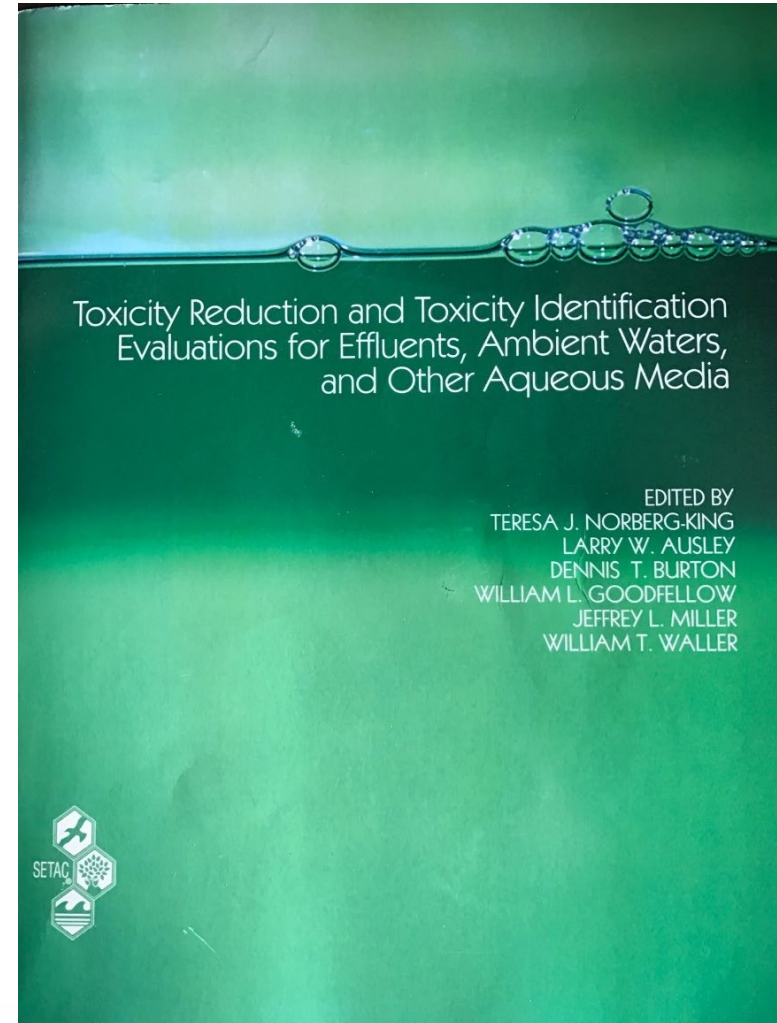
This report was prepared to assist those individuals and organizations concerned with Whole Effluent Toxicity (WET), and to help clarify the initial steps that lead to a Toxicity Identification Evaluation (TIE) or a Toxicity Reduction Evaluation (TRE).

This report was generated by the WET Expert Advisory Panel on TIE/TRE and peer reviewed by the WET Expert Advisory Panels Steering Committee, all volunteers and all members of the Society of Environmental Toxicology and Chemistry (SETAC). Each person involved is an expert in some aspect of WET, and the information provided here represents the consensus of the Panel on TIE/TRE and the Steering Committee's collective expertise at the time this

Prepared to provide assistance to individuals and organizations concerned with WET and to help clarify the initial steps that lead to the TIE or TRE.

Publication from the Technical Workshop

- This Pellston Workshop on TRE/TIE's book advanced the understanding of the TRE process and the science of TIE in aqueous effluents, surface water, and sediments.
- Comprehensive report detailing procedures and including more than 30 case studies describing various aspects of the process.
- Collaboration has been highly effective with biologists, chemists and engineers.



Summary

- Through collaborative, tripartite process, that included academia, industry, consultants, state and federal government, advancements in environmental toxicology were made with effluent testing and effluent TRE/TIEs.

