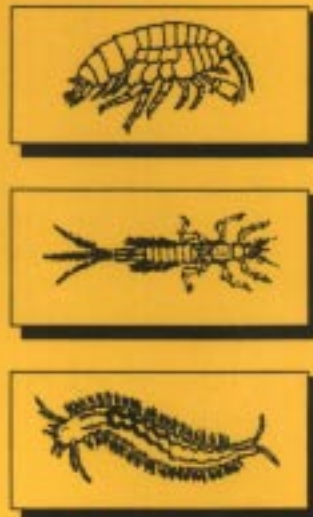


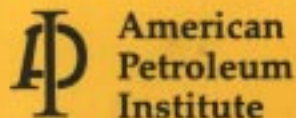


User's Guide: Evaluation of Sediment Toxicity Tests for Biomonitoring Programs

HEALTH AND ENVIRONMENTAL SCIENCES DEPARTMENT

API PUBLICATION NUMBER 4608

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Evaluation of Sediment
Toxicity Tests for
Biomonitoring Programs**

HEALTH AND ENVIRONMENTAL
SCIENCES DEPARTMENT

API PUBLICATION NUMBER 4608

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ABSTRACT

Sediment toxicity test methods are available for marine, estuarine, and freshwater sediments and organisms. The methods can be used for a variety of purposes: for example, assessment of existing environmental conditions, monitoring changes with time, or for NPDES permit compliance. Use of inappropriate test methods or species for a given purpose can impact the toxicity results and their interpretation. This User's Guide has been prepared to assist personnel at petroleum industry facilities (refineries, marketing terminals, and production locations) in understanding sediment toxicity testing and in the selection of test methods and species which are appropriate for their needs. The general aspects of sediment toxicity testing are summarized along with technical requirements and appropriate conditions for each test type. Test methods are evaluated for their reliability, ecological relevance, exposure relevance, availability, interferences, and ability to discriminate toxicants. A companion report (Technical Resource Document) has been prepared to provide detailed technical background information on the methods.

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INTRODUCTION

Reliable toxicity tests are currently available for testing of marine, estuarine, and freshwater sediments as part of biomonitoring programs for wastewater discharges. Sediment toxicity tests provide an integrated measure of the effects of sediment contamination that eliminates much of the uncertainty associated with predicting toxicity from sediment chemistry alone. When combined with surveys of animals living in the sediments, sediment toxicity tests can be used to assess existing conditions, rank sites for cleanup priority, and monitor changes in contaminant effects with time (Chapman *et al.* 1992). However, the use of inappropriate test methods or species and the failure to consider physical and chemical factors that can affect the results of the tests may diminish the value of biological toxicity testing (Burton 1991; Hill *et al.* 1993).

The purpose of this User's Guide is to provide information that will enable environmental personnel at petroleum facilities to select sediment toxicity tests and test methods that are scientifically valid and appropriate for a specific site. For those readers who are unfamiliar with sediment toxicity testing, this User's Guide explains general aspects of sediment toxicity testing and how to use available technical information. This document also outlines the technical requirements and appropriate conditions for using different sediment toxicity test methods. A companion document, *Evaluation of Sediment Toxicity Tests for Biomonitoring Programs* (PTI, 1994) hereafter referred to as the Technical Resource Document, has been prepared to provide technical background on the test methods and the detailed rationale for the evaluations presented here. The Technical Resource Document is intended to be used as a reference tool for the test selection process and also as an information resource to support negotiations with agencies concerning the appropriateness of any recommended tests.

Sediment toxicity tests anticipated for future use in biomonitoring programs for National Pollutant Discharge Elimination System (NPDES) permit compliance are addressed in the Technical Resource Document and in this User's Guide. These docu-

ments were developed for use by petroleum industry operations (refineries, marketing terminals, and production facilities) that have discharges to surface waters. However, the Technical Resource Document and this User's Guide contain information that is applicable to other industries and could be used by any wastewater discharger.

The term *sediment toxicity test*, as used here, refers to any laboratory method that measures the adverse biological response of a group of organisms to a sample of test sediment. Some sediment toxicity tests measure lethal effects by determining the number of organisms that are killed during the exposure period. Other tests measure sublethal effects such as developmental abnormalities in juvenile stages, inhibition of reproduction, or reduced growth. Sediment toxicity tests are used in many biomonitoring programs because they integrate the effects of multiple chemicals and can be used in conjunction with chemical measurements and surveys of sediment-dwelling organisms to establish cause-effect relationships. Sediment toxicity tests are also the primary tool for any toxicity identification and evaluation program. Sediment toxicity tests are available for many different species and various life stages of some species. For example, they may be conducted on embryos, larvae, and juveniles of various fish species, as well as embryos and juveniles of invertebrates such as clams, oysters, and sea urchins. Sediment toxicity tests can also be conducted with microscopic algae and bacteria, submerged aquatic plants (e.g., water hyacinth), and wetland plants (e.g., marsh grass).

The next section presents an evaluation of available sediment toxicity tests, including descriptions of habitat type, sediment test systems, and biological endpoints. The following section provides a procedure for selection of tests at a specific site. Finally, brief summaries of sampling and data analysis issues are presented in a section on application of sediment toxicity tests.

Selected terms in this User's Guide are defined in the Glossary.

EVALUATION OF SEDIMENT TOXICITY TESTS

The available test methods were classified by type of habitat (marine, estuarine, and freshwater) to which each method applies and the general endpoint type (lethal or sublethal) specified for each test. This classification scheme resulted in the following six major categories of tests:

- Marine lethal
- Marine sublethal
- Estuarine lethal
- Estuarine sublethal
- Freshwater lethal
- Freshwater sublethal.

Appendix A of the Technical Resource Document presents test classification tables that contain the following information on each test: 1) organisms, including the broad biotic group, scientific name, and life stage of the species used in the test; 2) exposure medium (whole sediment, interstitial water, sediment elutriate, or sediment extract); 3) exposure duration; and 4) primary literature references for test methods. Each test was assigned a number to allow users of the Technical Resource Document to track a given test through the various evaluation tables. In many cases, several of the specified tests were actually variations of a single test method and were assigned the same test number.

KEY TEST CHARACTERISTICS

The key characteristics used to classify sediment toxicity tests are described below (see the *Test Screening Approach* section of the Technical Resource Document for details).

Habitat Type

The primary characteristic that distinguishes marine, estuarine, and freshwater habitat types is water salinity. Salinity strongly influences the distributions of most of the test organisms. In some cases, test organisms are tolerant of both marine and estuarine conditions or both estuarine and freshwater conditions. However, few test organisms tolerate both marine and freshwater conditions. For purposes of this study, habitat categories were defined as follows:

- Marine (≥ 28 ppt)
- Estuarine (> 0.5 ppt and < 28 ppt)
- Freshwater (≤ 0.5 ppt).

Because the division between habitat categories is an artificial distinction, use of a particular habitat designation for a test in this report should not necessarily preclude the application of a test to sediments in other habitats. For example, some tests that are classified as marine tests may be applied to high salinity estuarine sediments, and in some cases, adjusting the salinity of a sediment sample to allow the use of a particular test may be appropriate.

Exposure Medium

The kind of exposure medium was used to classify the various toxicity tests because each kind of exposure medium has favorable and unfavorable characteristics that can profoundly influence the toxicity test results. The four kinds of exposure media considered were as follows:

- Whole sediments
- Interstitial water
- Sediment elutriates
- Sediment extracts.

Whole Sediments—The use of whole sediments is probably the most realistic exposure scenario because it mimics the manner in which most organisms are exposed to chemicals in the

environment. Whole-sediment toxicity tests integrate multiple exposure routes, including chemical intake from dermal contact with sediment particles and interstitial water as well as ingestion of sediment particles, interstitial water, and food organisms (the food uptake route applies to at least some methods in which the test species is not fed). For most whole sediment tests, the sediments are carefully placed in the exposure chamber and the chamber is then filled with clean water. Resuspended particles are allowed to settle before initiation of exposure. In whole-sediment tests, infaunal test organisms are expected to have the highest potential for exposure to chemicals because they live within the sediments.

Interstitial Water—Interstitial water as an exposure medium is prepared by removing water from the test sediments by methods such as filtration and centrifugation. The test organisms are then introduced to the interstitial water in the absence of sediments. For infaunal organisms, interstitial water is a representative exposure medium for primarily one exposure route (i.e., dermal contact with the dissolved forms of chemicals). Interstitial water is not a representative exposure medium for epifaunal, planktonic, and nektonic organisms. The degree to which the sampling of interstitial waters or the elutriation process modifies the toxicity of the sample is usually unknown.

Sediment Elutriates—Sediment elutriates are prepared by mixing sediments and test water for a fixed period of time and then removing the sediments by methods such as filtration, centrifugation, and decanting after a settling period. The test organisms are then introduced to the test water in the absence of sediments. Elutriates are useful for representing the exposure to chemicals that can occur after sediments have been resuspended into the water column or after they have passed through the water column as part of dredged material disposal operations. Although the use of a sediment elutriate as an exposure medium is realistic for planktonic and nektonic test organisms, it is unrealistic for infaunal and epibenthic organisms. The degree to which the sampling of interstitial waters or

the elutriation process modifies the toxicity of the sample is usually unknown.

Sediment Extracts—Sediment extracts are prepared by mixing sediments with an organic solvent that is capable of removing specific kinds of chemicals from the sediments. After the extraction process is completed, the sediments are removed by methods such as filtration, centrifugation, and decanting after a settling period. The extractant and the extracted chemicals are diluted with water for testing. In some cases, the extracted chemicals are first exchanged with a less toxic carrier medium before the test concentrations are prepared. In either case, the test organisms are introduced to a solvent-water mixture containing the extracted chemicals. Because the test organisms are exposed to an unnatural exposure medium (organic solvent) in the absence of sediments, an extractant-prepared exposure medium is generally considered an unrealistic exposure scenario.

Endpoint Type

The major types of endpoints for most toxicity tests include the following:

- Lethal (i.e., mortality)
- Sublethal
 - Reduced growth
 - Reproductive effects
 - Developmental abnormality
 - Histopathological abnormalities.

The determination of the lethal endpoint is unambiguous and is clearly an adverse effect. The reliability of any sublethal endpoint test depends on use of experienced laboratory personnel (for details see *Endpoint Type* in the section *Classification of Available Test Methods, Classification Criteria* in the Technical Resource Document).