Summary

The primary role of the ASTM symposium series on aquatic toxicology is to provide a forum for discussion of recent developments that are important to those who perform environmental risk assessments and who work in ecotoxicology and environmental chemistry. The success of the eleventh symposium in fulfilling this role is shown in the 38 papers appearing in this publication. These papers, continuing the trend of previous meetings, include topics significant to the standard-writing process, such as chronic endpoints, statistical data analysis, and description of new methodologies. In addition, sections of this volume are devoted to three subjects that are becoming increasingly important to the scientific and regulatory communities. The number of papers in the section on effluent toxicity assessments reflects the increasing importance of the U.S. Environmental Protection Agency's national policy of control of toxic substances on the basis of water quality. The large section on current developments in understanding the fate of chemicals reflects the recent recognition of the importance of realistic exposure assessments. Likewise, the realization that not all species, chemicals, and conditions can be tested or measured has resulted in high interest in quantitative structure-activity relationships and similar models. Key aspects of these fields and brief summaries of the papers in this volume follow. It can be expected that the information presented in these papers will serve as a focus for future presentations at ASTM symposia in this series. This expectation reflects the dynamic and ever-challenging nature of aquatic toxicology, risk assessment, and the standard-writing process.

Fate of Chemicals in Water and Sediment

Understanding the fate of chemicals in the environment is obviously important in risk assessment and management. Two papers in this volume describe fate and risk assessment models. *Nocito et al.* present a risk framework for marine disposal of sludge. The procedure uses the risk information system of the U.S. Environmental Protection Agency (EPA) and represents a preliminary assessment of ecological and human health risks associated with municipal waste disposal. A model for predicting the effects of dredged material plumes in Long Island Sound is described by *Munns and Paul.* The model provides reliable estimates of suspended solid concentrations and specific contaminant levels in the ecosystem when compared with *in situ* measurements. The toxicity of percolate from decontaminated pesticide-contaminated soils is described by *Graves et al. Cowgill* discusses the chemical dynamics of the mud-water interface in aerobic and anaerobic eutrophic lakes. It was found that the elements in anaerobic muds of Linsley Pond (Connecticut) diffuse into the hypolimnion, whereas those in aerobic muds of Lake Hubeh (Israel) either diffuse in conjunction with the ferric hydroxide complex or are retained by organic matter.

Several papers describe the biodegradation potential of pure compounds and the fate of chemicals in estuarine and freshwater systems. *Adams et al.* measured the biodegradation of butyl benzyl phthalate (BBP) in water and sediment during a 30-day microcosm study. The data show that BBP is readily degradable in water and sediment. The half-life in water was 2.0 days or less. It was also found that BBP metabolites were 100 times less toxic to

Daphnia magna than the parent compound. The response of microbial communities in rivers and lakes to three detergent surfactants was studied by *Ventullo et al.* Exposure for 3 h to 23 days had no detrimental effect on bacterial heterotrophy, and chronic exposure resulted in an adaptive response, indicated by increased degradation of the chemicals after exposure. *Sanders and Abbe* found that silver uptake in estuarine and marine phytoplankton is rapid and inversely proportional to the salinity. Diatoms and dinoflagellates were considerably more sensitive to silver than other flagellated species. The authors state that integrated studies are needed to determine the health of estuarine and marine ecosystems. *Fulthorpe et al.* describe the influence of chemical concentration and the presence of mixtures of aromatic contaminants on the catabolic activities of bacteria. According to the authors, some species isolated from natural streams evolve unstable catabolic phenotypes.

Effluent Toxicity

The primary objective of the EPA's water-quality-based toxics control program is to prevent the entry of toxic effluents into the Nation's receiving waters. Nine papers address effluent assessment techniques and site-specific safety evaluations. An automated biological early warning system for detecting acutely toxic effluents is presented by *Gruber et al.* The computerized system measures the ventilatory responses of bluegill and was found to be useful and reliable in a validation study. A fractionation procedure for effluents using simple column chromatography techniques is described by *Doi and Grothe.* The fractionation format proved very useful in identifying toxic components in environmental samples. Two examples of the effects of effluents on marine ecosystems are presented. *Schimmel et al.* conducted an on-site evaluation of the toxicity of a pulp mill discharge using five test species. Sea urchins and an alga were the most sensitive test organisms. Unionized ammonia was the primary toxic constituent. *Frithsen et al.* conducted a four-month project to evaluate the ability of two test methods to detect the toxicity of sewage effluents in coastal areas. The methods were a single-species test (sea urchin) and outdoor mesocosms. The authors concluded that the single-species test was useful for indicating the magnitude and persistence of toxicity, and the mesocosms identified sensitive components and processes. *Westerman* evaluated the effects of point and nonpoint pollution sources in the Yellow Creek drainage in Kentucky. Sediment toxicity tests were useful for describing long-term impacts, while water column tests were more representative of short-term effects. Sediment toxicity testing was preferred, therefore, for assessing in-stream effects. *Goodfellow et al.* found *Ceriodaphnia dubia* to be more sensitive to a municipal wastewater effluent discharged into Baltimore Harbor than *Mysidopsis bahia* and Microtox. The utility of these data are discussed in the context of a toxicity reduction evaluation. *Pratt et al.* determined the effects of a municipal effluent containing textile dyes on bacterial communities, invertebrates, and fish. The bacterial microcosm tests were less sensitive than the single-species tests in detecting toxicity. *Finlayson and Wilson* determined the effects of acid mine waste on salmonids and monitored metal levels in the receiving water for potential toxic effects. They suggest that new criteria are needed for receiving water if effective protection is to be afforded. *Freeman et al.* investigated the effects of mitigating low pH levels on Atlantic salmon. A salt-enriched diet appeared to be helpful, as was neutralization with limestone.

Chronic Endpoints: Statistical Versus Biological Significance

The experience accrued in chronic toxicity testing has made it clear that application of hypothesis testing statistics to individual measured responses of test organisms results in

endpoints that are inconsistent and, in some cases, that would not protect populations. There is no consistent relationship between statistical significance and biological significance, and equal changes in two responses, such as growth and mortality, do not have equal significance. Two suggested changes in the endpoints are (1) use of an integrated population response parameter rather than individual measured responses, and (2) use of concentrations that cause particular levels of effect rather than concentrations that differ from controls at some level of statistical significance. New insights concerning this problem are provided in this volume. *Stephan* summarizes current thinking concerning the analysis of chronic toxicity test results. The author discusses appropriate endpoints, terminology, and statistical data treatments. He stresses that these issues need to be resolved before additional chronic toxicity studies are developed. The utility of the instantaneous rate of increase, *r*, as an effect parameter is examined by *Barbour et al.* This parameter was found to be a valid measure of toxicity, based on a review of 100 chronic toxicity tests with *Ceriodaphnia*. However, it was not more sensitive than other chronic endpoints and is not cost-effective to calculate. *Barnthouse et al.* state that biological significance, for which there is no uniform definition, cannot be derived from the statistical significance of test results. Barnthouse and his co-workers show how simple population models developed for assessing effects of fishing and power-plant-induced mortality on fish populations can be used to summarize and interpret chronic toxicity test results and provide a basis for inferring biological significance.

Statistical Procedures

Advances in the statistical analysis of toxicity test results and the validation of various data analysis procedures are discussed in four papers. *Staples and Sebaugh* evaluate sensitivity and uncertainty analysis for use with chemical environmental exposure models. The utility and efficiency of the Latin hypercube sampling method is demonstrated using a sample data set. The effect of withdrawals during chronic toxicity tests is addressed by *Groggel et al.* A withdrawal is an observation that exists in the study prior to the measurement of the variable of interest, and only the value up to that point in time is noted. The authors note that results of studies with high withdrawal rates and unequal sample sizes are misleading. Two papers evaluate the available computer programs in their ability to conduct probit analyses. *Bromaghin and Engeman* evaluate the ASTM proposed standard practice for using probit analysis and compare it with a well-known SAS package. They conclude that the ASTM program is a subset of the SAS procedure and recommend that the ASTM program be expanded. *Roberts* has compared the analysis of 20 data sets with four software packages and found that most of the programs provide consistent results.

Microcosms

Numerous papers in previous ASTM publications in this series have described various microcosm and field testing procedures. The validation, reproducibility, and utility of these assessment techniques, however, have been rarely described. Two papers in this volume provide this information for one proposed test method called the standardized aquatic microcosm (SAM). SAM has been used in seven experiments by four laboratories, as reported by *Taub et al.* All the SAM experiments conducted with copper exhibited the same sequence of events, although the timing of the effects varied. Copper initially eliminated *Daphnia* and reduced algal populations, but the algae rapidly recovered. *Landis et al.* recommend the use of this microcosm based on their experience with three test com-

pounds. The primary advantage of its use is the capability of this method to observe effects and fate simultaneously; the key disadvantage is the amount of labor required.

QSARs and Other Data Extrapolations

Many of the chemicals entering the environment lack comprehensive fate and effects data. Predictive equations to provide these data are obviously helpful to risk assessment managers. Several papers report QSARs (quantitative structure-activity relationships) for various compounds, species, and endpoints. A model to estimate LC_{50} values for *Daphnia magna* from rat oral LD_{50} values and molecular descriptors based on 190 chemicals is presented by *Enslein et al.* A model is also presented by *Niemi and Veith* for classification of chemicals as biodegradable or persistent under conditions used in conventional waste treatment. The authors indicate that the usefulness of this model would greatly increase if a BOD data base existed for chemicals with a wider variety of structures. *Schultz et al.* present models to predict the acute toxicity of various compounds to the ciliate *Tetrahymena pyriformis.* The effects of pyridines, cyanobenzenes, phenols, and benzyl alcohols, among others, are included. *Lipnick* describes the relationship of the toxicity of alcohols, saturated monoketones, and hydrocarbons to the tadpole, *Rana temporaria. Holcombe et al.* describe a method that uses acute toxicity data for the fathead minnow to predict effects on communities of organisms.

Standard QSARs do not reliably predict effects for some compounds. One such example is presented by *Kaiser and Gough* and is based on the acute response of *Photobacterium phosphoreum* to mono-substituted benzenes. *Roberts* reviews various QSARs reported in the literature for chemicals shown to be more toxic to fish than predicted. These predictive equations are based on electrophilicity parameters for which the chemical basis is discussed.

Walker and Brink describe a new procedure that the Interagency Testing Committee (ITC) is using to select chemicals for toxicity screening. This procedure utilizes expert panels of ecologists, engineers, chemists, and toxicologists to recommend target chemicals. These panels have identified 250 compounds having the potential for toxicity. *Riedel* presents a means of extrapolating the effects of hexavalent chromium on phytoplankton based on the sulfate concentration in fresh water and correlating these data with the salinity of marine and estuarine waters.

New Methods for Aquatic Toxicology

New test methods and improvements to established methods are constantly needed by the scientific and regulatory communities. Three papers in this volume describe recent developments in this area. *Stehly and Hayton* evaluate the ability of the commonly used accelerated bioconcentration test to predict BCF values for lipophilic compounds and fish. Differences between the calculated and estimated values are as great as 95%. The discrepancy in values could be reduced by considering the fit to multicompartmental models. A programmable microcomputer control system is described by *Voyer et al.* which permits the study of the effects of fluctuating salinity on responses of estuarine organisms to chemicals. The apparatus (eight-bit microcomputer) has been used in toxicity tests to confirm that cadmium toxicity increases with decreasing salinity. *Blondin et al.* present a bioassay based on metabolic changes in isolated animal mitochondria. Effects data on electron transfer and transport systems are obtained in 2 to 15 min. The correlation between fat-

head minnow acute lethality and mitochondria toxicity for 44 test compounds was greater than 85%, which is better than the correlation between fish toxicity and the commonly used Microtox procedure.

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