Monitoring Water in the 1990's

Meeting New Challenges

HALL / GLYSSON
EDITORS

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Monitoring Water in the 1990's: Meeting New Challenges

Jack R. Hall and G. Douglas Glysson, editors

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Foreword

This publication, *Monitoring Water in the 1990's: Meeting New Challenges,* contains papers presented at the symposium of the same name, held in Denver, CO on 11-14 June 1990. The symposium was sponsored by ASTM Committee D-19 on Water. Jack R. Hall of the IT Corporation in Knoxville, TN and G. Douglas Glysson of the U.S. Geological Survey in Reston, VA presided as symposium co-chairmen and are editors of the resulting publication.

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Overview

The purpose of the Symposium on Monitoring Water in the 1990s: Meeting New Challenges was to provide a forum for industrial, governmental and environmental scientists to present and discuss problems affecting water monitoring as well as evaluating potential solutions based on current research and state-of-the-art technology.

A secondary purpose of the symposium was to stimulate interest in the efforts of ASTM Committee D-19 on Water and the thirteen subcommittees involved in water treatment, measurement and monitoring. The symposium was unique because it represented the diverse disciplines of the total ASTM Committee D-19 covering statistical evaluation of data and method validation, sampling and flow measurement, radiochemical and mixed waste analyses, organic and inorganic constituent analyses, sediments, geomorphology and open-channel flow, microbiology, saline water methodology, water for power generation and process use and identification of waterborne oils.

Geraldine V. Cox, Vice President and Technical Director, Chemical Manufacturers Association (CMA) presented the Keynote address on "Monitoring More -- Measuring Less and Less." The address clearly presented the challenges for biologists, hydrologists, toxicologists, chemists and other environmental scientists to assure the validity of environmental data.

This publication of the proceedings contains 44 papers presented at the symposium. Authors include front line researchers and known authorities in their fields. All papers have undergone critical peer review by ASTM approved reviewers in accordance with ASTM publication criteria. These proceedings should prove useful to all disciplines dealing with the generation, use and interpretation of water data.

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Keynote Address

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MONITORING MORE -- MEASURING LESS AND LESS

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ABSTRACT: Scientists need to improve understanding of the significance of analytical results relative to the environment. Scientific methodology has progressed yielding an impressive ability to measure minuscule quantities of contaminants, but the ability to understand the significance of those levels in the environment has not kept pace. Scientists must also improve their ability to accurately measure materials in complex matrices. The third area requiring attention in this decade is sampling protocols. Too much contamination and improper sampling strategies are negating the accuracy of high-precision analytical efforts. These are the challenges of the 1990s.

KEYWORDS: trace analyses, matrix interaction, interpreting data.

INTRODUCTION

The 1990s offer a challenge to environmental scientists. In the past decades we have become extremely proficient in our ability to measure infinitesimal concentrations of contaminants in water. We have not been as proficient in our ability to interpret the values derived from these analyses.

Biologists are hard-pressed to interpret the significance of the small values found in water. Environmental scientists must develop more refined exposure and hazard

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assessment technologies to parallel our sophisticated analytical capabilities.

Understanding the significance of trace concentrations doesn't come simply by using a mathematical model that approximates the observed -- and "corrects for the unexplained variations." The real challenge still facing us is to understand the physiological changes -- acute and chronic -- caused by trace chemicals. This understanding is on a molecular model level, an organ level, an organism level and an ecosystem level. Scientists have real opportunities to refine their understanding of species distribution changes caused by chemical and biological alteration. Armed with this understanding, we can improve mathematical models to become accurate predictors of impact -- based on our true understanding of the mechanisms of action. Without this basic understanding, models are no more than educated guesses.

Another challenge for the future is to improve sampling technology. Sampling technology has not improved with the same speed as our analytical capabilities. Environmental scientists have not focused sufficient attention on collecting, storing, transporting and preparing samples before analysis. This gap represents the greatest remaining area of error in environmental analyses. The 1990s should see more focus on sample collection techniques: how, when, where, and how often. Sample preservation and storage, prevention of contamination, proper sampling equipment and sampling methodology are critical to good sample results. While sampling technology is not a glamor area for research, sampling techniques and matrix interferences remain the greatest areas of error in analytical chemistry of the environment. What good is the most accurate analytical technique if the sample is contaminated or not representative in the first place?

Analytical chemists have advanced the field of measuring with the speed of light in the past decade. Now it is time to focus on the supporting areas to assure that they have the same level of precision and accuracy.

THE DILEMMA OF THE ENVIRONMENTAL ANALYST

The topic of this paper is Monitoring More -- Measuring Less and Less. This is an interesting situation because analysts are developing sophisticated methods for measuring trace contaminants in environmental samples -- food, water, sediments, and plant and animal tissue. Too often the mere fact that these materials are present in barely detectable quantities will make headlines. However, biologists simply do not know what these levels mean to plants, to animals, to ecosystems and, especially, to humans.

Toxicology is an infant science, although it is developing more useful tests. We know what the effects of a compound are when we expose an animal to very high concentrations, but we do not understand the effects of low level exposures. Toxicological tests are conducted with high levels of exposure to get statistically significant levels of response. This high-level dosage protocol swamps biochemical pathways so that, in many cases, the normal metabolic pathways are not used. Animal models used for testing are traditionally chosen for the convenience of the laboratory, e.g., rats and mice, not on the ability of these animals to mimic human metabolism. Fortunately, as our understanding of toxicology increases, more pharmacokinetic studies are conducted prior to long-term testing to determine if the metabolism of the test compound bears any relationship to humans.

Environmental toxicology is even further behind than mammalian toxicology. We are still using wild species and have much less control over the testing conditions than we do with traditional mammalian toxicology. So-called "ecotoxicity" rarely is. "Ecotoxicity" tests single species or several species, and is not a test of the ecosystem. That is, few tests measure the interaction of species to each other in relationship to the test material. Pound trials used to test new pesticides are the best attempt to measure an ecosystem subset in a regulatory scheme.

Extrapolation of toxicologic test results to low levels found in environmental concentrations becomes very problematic. We have no good verification base for low dose exposures. Years ago, the Food and Drug Administration, FDA, the National Institute for Occupational Safety and Health, NIOSH, and other regulatory agencies, funded a study conducted at National Center for Toxicology Research, NCTR, in Pine Bluff, Arkansas to determine, once and for all, the shape of the low exposure response curve. The study was commonly known as the "Megamouse Study." In this study, many thousand mice -- I think the starting number may have been as large as 25,000 -- were subjected to low concentrations of a known carcinogen. The results of the long-term carcinogen study were indeterminate, and the advocates of both linear extrapolation and the threshold theory believed that their theory was proven.

If one believed the so-called "conservative" hazard assessments of the government, particularly considering the collective exposures to trace contaminants, we should not enjoy anywhere near the life expectancy that we have now. Recent studies show that "natural" chemicals may be more potent carcinogens than most man-made chemicals. Therefore, the role of chemicals in carcinogenicity may be much less than natural factors. Clearly it is less than other factors that we can control such as tobacco use, diet and alcohol consumption.

The uneven approach of linking exposure data to toxicological data to form risk assessment has brought many interesting situations. In his February 26, 1990 editorial, Not all Risks are Equal, that appeared in The Detroit News, Warren Brookes featured the inconsistency.

Two weeks ago the U.S. Department of Agriculture (USDA) proposed that all American corn for export be tested for the presence of aflatoxin, which is known to be a powerful cancer-causing agent. The department didn't mention one of the main causes for the rising level of aflatoxin in the U.S. grainbelt; namely, the banning by the Environmental Protection Agency (EPA) of the fumigant ethylene dibromide (EDB).

When fed to rats, EDB has been found to produce cancer. Yet even at the maximum levels of exposure, EDB is 1,000 time less carcinogenic than aflatoxin. So, by eliminating EDB, the EPA subjected consumers to 1,000 times greater relative health risks. And all for nothing; EDBs are about half as carcinogenic as the chloroform levels in most city tap water.

Such stringent regulation is mandated by Congress under the so-called Delaney Clause of the 1958 Food, Drug and Cosmetic Act. This clause requires that any chemical used in foods must be banned if it shows any carcinogenicity, or tendency to cause cancer, no matter how infinitesimal the risk.

Earlier this month the Food and Drug Administration was forced for the same reasons to ban Red Dye No. 3, a food coloring agent, even though Health and Human Services Secretary Louis Sullivan readily admitted "the actual risk posed by Red No. 3 is extremely small." How small? About 1/1000 the level of toxicity of EDB.

Environmentalists believe that any added exposure to toxic substances places man in peril. They oppose risk-benefit analyses. As Janet Hathaway of the Natural Resources Defense Council put it recently: "Allowing the EPA to condone continued use of a chemical whenever the benefits outweigh the risks is absolutely anathema to the environmental community."

When it comes to something like AIDS, however, there seems to be a different standard. Last December, the makers of AZT, a drug that helps alleviate the suffering of AIDS victims, announced that AZT had been found to produce cancers in lab animals. They quickly added, however, that "the benefits of the drug far outweigh any possible risks," a view strongly backed by AIDS activists. Dr. Mathilde Krim of the American Foundation for AIDS Research, for example, noted that "Those (rodent) tumors all came on the highest dose, much higher than would be given to human beings . . ."

Precisely. Yet the same can be said for tests purporting to show that many pesticides are "cancer-causing." On average, rodent-test dosages are 20,000 to 40,000 times the level of the most exposed humans, which in turn can be anywhere from 300 to 300,000 times as much exposure as mo4t people receive, scientists say.

A team at Stanford University's Food Research Institute found that when actual exposure

is considered, not a single fungicide was found to produce even a theoretical additional cancer risk of one in a million. In other words, heading off a total of 250 additional risks of cancer during the lifetime of the American people will cost more than the entire annual budget of the National Cancer Institute -- which is trying to find ways to reduce the 900,000 actual cancers a year in the United States.

The EPA calculates that the current cancer risk from all food chemicals still being used under FDA registration is 6,000 in a million. The Stanford experts believe the number is closer to three in a million. The reason for the variance: It's almost impossible to directly prove that a single substance causes cancer. The risk numbers are entirely theoretical. From many substances, there may be no risk at all.

Even at 6,000 in a million, that's less risk than getting killed while driving your car (16,800 in a million) or cigarette smoking (252,000 per million). And if the California researchers are correct, the risk pales by comparison with that taken by frequent flyers on airplanes, (3,500 in a million) or being struck by lightning (35 in a million).

No wonder two of the world's leading epidemiologists, Oxford's Sir Richard Doll and Dr. Richard Peto, concluded back in 1981 that "the occurrence of pesticides as dietary pollutants seems unimportant." They noted that "there has been no increase in the incidence of liver tumors in developed countries since the long-lasting pesticides were introduced." Yet those are exactly the kind of tumors now produced in all rodent experiments.

Cancer is just one of many factors that we must consider when we look at the impact of trace contaminants in the environment. I'll suggest one example -- climate change.

We have trouble predicting the chemistry of the atmosphere as well as the effects of trace gases on the atmosphere -- not to mention these interactions with the physical and biological environment. We do not understand feed back loops in ecosystems. We do not understand the role of physical interaction of clouds, oceans, etc., on the climate change and "greenhouse gases." Many solutions are proposed in the political systems, but the science to understand causes and effects and to analyze the impacts of these proposed solutions is missing.

Scientists at the National Center for Atmospheric Research in Boulder, Colorado, are documenting the levels of isoprenes and turpenes in the Southeastern United States, Africa and South America. They find that the concentrations of these natural products follow the tropospheric ozone concentration and are responsible for significant ozone formation. Ozone, and the atmospheric chemistry that it triggers, are significant contributors to the localized "greenhouse gases." Isoprenes come from