

EXECUTIVE SUMMARY

A two-day workshop, entitled “Tropical Water Quality Indicator Workshop”, was held at the Waikiki Beach Marriott Resort in Honolulu on March 1–2, 2001. The primary funding agency for this workshop was the U.S. Environmental Protection Agency’s Office of Water, with matching funds provided by the Department of Health, State of Hawaii, and by the Water Resources Research Center, University of Hawaii. Mr. Rick Hoffmann of USEPA was the project officer and Dr. Roger Fujioka of Water Resources Research Center served as the workshop coordinator. The overall goal of this workshop was to address issues identified under the “Tropical Indicators” section of the EPA Action Plan for Beaches and Recreational Waters (EPA/600/R-98/079), which is restated below:

Tropical Indicators

Currently recommended fecal indicators may not be suitable for assessing human health risks in the tropics. Studies have suggested that at tropical locales such as Puerto Rico, Hawaii, and Guam, *E. coli* and enterococci can be detected in waters where there is no apparent warm-blooded animal source of contamination.

Whether or not current indicator bacteria proliferate naturally in soil and water under tropical conditions must be determined. If so, the range of conditions (such as nutrients, temperature, pH and salinity) under which the bacteria proliferate will be characterized and their geographical boundaries defined. If the phenomenon is widespread under tropical conditions, additional research will be conducted to modify approaches for monitoring, or to develop new tropics-specific indicators. Further evaluation of *Clostridium perfringens* and other microbial indicators (including coliphages) that do not flourish naturally in the tropics will be conducted to determine their usefulness as alternative indicators.

To address the above problem, a total of 18 national and international experts were selected to participate in the workshop. Selection was based on their established professional reputation and expertise in water quality microbiology and some applicable working knowledge of water quality problems in tropical areas. The 18 experts are listed below:

1. Eugene Akazawa, Department of Health, State of Hawaii, Honolulu, Hawaii
2. Nicholas J. Ashbolt, Ph.D., University of New South Wales, Sydney, Australia
3. Christine Bullock, Institute of Marine Affairs, Trinidad, West Indies
4. Muruleedhara Byappanahalli, Ph.D., University of Hawaii, Honolulu, Hawaii
5. Alfred P. Dufour, Ph.D., USEPA, Cincinnati, Ohio
6. Roger S. Fujioka, Ph.D., University of Hawaii, Honolulu, Hawaii
7. Charles P. Gerba, Ph.D., University of Arizona, Tucson, Arizona
8. Terry C. Hazen, Ph.D., Lawrence Berkeley National Lab, Berkeley, California
9. Rick Hoffmann, USEPA, Washington, D.C.
10. Gillian Lewis, Ph.D., University of Auckland, Auckland, New Zealand
11. David M. Morens, M.D., National Institutes of Health, Bethesda, Maryland
12. Joan B. Rose, Ph.D., University of South Florida, St. Petersburg, Florida
13. Michael Sadowsky, Ph.D., University of Minnesota, St. Paul, Minnesota
14. Carmen Sian-Denton, Guam Waterworks Authority, Agana, Guam

15. Stephen Schaub, Ph.D., USEPA, Washington, DC
16. Helena Solo-Gabriele, Ph.D., P.E., University of Miami, Coral Gables, Florida
17. James M. Tiedje, Ph.D., Michigan State University, East Lansing, Michigan
18. Gary A. Toranzos, Ph.D., University of Puerto Rico, San Juan, Puerto Rico

Recognizing that regulators and other members of the agencies involved in water quality would be interested in this workshop, a decision was made to invite a limited number of “observers”, who were defined as those with relevant experience from a regulatory or environmental perspective. The 14 observers who attended this workshop are listed below:

1. Kristen P. Brenner, USEPA, Cincinnati, Ohio
2. Barbara Genthner, University of West Florida, Pensacola, Florida
3. Fred Genthner, USEPA, Gulf Breeze, Florida
4. Gary Gill, Department of Health, State of Hawaii, Honolulu
5. Joel Hansel, USEPA, Atlanta Georgia
6. June Harrigan, Department of Health, State of Hawaii, Honolulu
7. Janet Hashimoto, USEPA, San Francisco, California
8. John Oka, County of Maui, Wailuku, Maui, Hawaii
9. Sara Rosa, USEPA, San Francisco, California
10. Robert Rychlinsky, County of Maui, Wailuku, Maui, Hawaii
11. Charlotte Spires, Food and Drug Administration, Rockville, Maryland
12. Ross Tanimoto, City and County of Honolulu, Honolulu, Hawaii
13. Terrance Teruya, Department of Health, State of Hawaii, Honolulu
14. Richard Whitman, USGS, Porter, Indiana

The format of the two-day workshop was to have scheduled speakers address problem statements selected for each day’s morning session and to have all experts discuss the results of the morning presentations and to reach consensus conclusions and recommendations during the respective afternoon sessions. Each afternoon session’s chair was selected from among the invited experts to lead the day’s discussion. The session chairs were selected based on their acknowledged leadership among the experts and based on their non-involvement in monitoring of the tropical environment. Dr. Charles Gerba (University of Arizona) was selected to chair the afternoon session on day one and Dr. James Tiedje (Michigan State University) on day two. The specific task of the session chair was to lead the discussion among the experts for the purpose of assessing the presentations and developing concluding statements. All of the experts contributed in crafting each concluding statement. The degree of consensus for the concluding statement was determined by a hand vote that indicated how many experts agreed, disagreed, or abstained from voting. After the voting, the concluding statement was called the consensus statement. The consensus statements represent general or collective opinion of workshop participants but not 100 percent agreement in most cases.

To help the experts prepare for this workshop, each was sent a packet of relevant research papers on current tropical water quality issues. These papers represented a collection of reports on research to be discussed at the workshop. The invited experts were also sent a

guidance document, which provided detailed information about the objectives and format of the workshop. The guidance document included five agenda questions of concern. During the workshop, the experts discussed the findings related to these five questions and developed consensus statements in response to these questions. The five agenda questions are listed below, followed by the appropriate consensus statements crafted by the experts.

Agenda question one

Are there sufficient experimental and monitoring data to conclude that the assumption used in interpreting water quality standards (there are no significant environmental sources of fecal coliforms, *E. coli*, and enterococci) is not applicable in tropical areas (Hawaii, Guam, Puerto Rico, south Florida) because these bacteria can be recovered in high concentrations from ambient environments (water, soil, plants) in these areas?

Consensus statement one

Soil, sediments, water, and plants may be significant indigenous sources of indicator bacteria in tropical waters.

This statement was crafted in response to Agenda Question One. All 18 (100%) of the experts voted in support of this consensus statement.

Agenda question two

Are there sufficient experimental and monitoring data to conclude that the EPA criteria (*E. coli*, enterococci) used to assess the quality of environmental waters are not reliable in tropical locales (Hawaii, Guam, Puerto Rico, south Florida) because the selected fecal bacteria persist in these ambient environments and represent non-fecal contamination?

Agenda question three

Are there sufficient experimental and monitoring data to conclude that the EPA-recommended recreational water quality standards are not suitable to assess the hygienic quality of environmental waters in Hawaii, Guam, Puerto Rico, and south Florida?

Consensus statement two

The inherent environmental characteristics of the tropics affect the relationships between indicators of fecal contamination (*E. coli*, fecal coliforms, enterococci) and health effects observed in bathers, which may compromise the efficacy of EPA guidelines.

This statement was crafted in response to Agenda Questions Two and Three. Sixteen of eighteen experts (88.8%) voted to support this statement. Two experts abstained from voting.

Agenda question four

Are there sufficient experimental and monitoring data to conclude that fecal indicator bacteria (fecal coliforms, *E. coli*, enterococci) can multiply in tropical environments and that bacteria from these sources are indicative of lower health risk than those from fecal sources?

Consensus statement three

Fecal indicator bacteria (fecal coliforms, *E. coli*, enterococci) can multiply and persist in soil, sediment, and water in some tropical/subtropical environments (Hawaii, Guam, Puerto Rico, south Florida).

This statement was crafted to address the issue of multiplication of fecal indicator bacteria in tropical environments (Agenda Question Four). Seventeen of eighteen (94.4%) experts voted to support this statement. One expert abstained from voting.

Agenda question five

Are there sufficient experimental and monitoring data to conclude that the proposed alternative criteria and recreational water quality standards for Hawaii and Puerto Rico are more useful than the current EPA criteria and standards?

Consensus statement four: The preferred version

Recreational water quality guidelines for the tropics/subtropics should be supplemented with additional alternative indicators (*C. perfringens*, coliphages) for watershed assessment (or sanitary survey).

This statement was crafted in response to the question of the usefulness of alternative fecal indicators for tropical environments (Agenda Question Five). Thirteen of eighteen (72.2%) experts preferred this statement, while five of eighteen (27.7%) accepted this statement but preferred an alternate statement.

Consensus statement four: The alternate version

In the absence of a predominant point source pollution, recreational water quality guidelines for the tropics/subtropics should be supplemented with additional alternative indicators (*C. perfringens*, coliphages) for watershed assessment (or sanitary survey).

Some experts wished to express this consensus statement differently. As a result, this alternate version was crafted. Five of eighteen (27.7%) experts preferred this version, while thirteen of eighteen (72.2 %) found this statement to be acceptable.

Two reasons were offered as to why some preferred the first version while others preferred the second. Those who voted for the preferred version indicated that it is a more protective and conservative approach. The statement recommends the necessity for using alternate indicators to supplement the traditional methods by which monitoring of the quality of recreational waters in tropical/subtropical regions should be done. Those who voted for the alternate version indicated that it is applicable in a situation where some preliminary studies have already determined the absence of a predominant point source of pollution and the ineffectiveness of the standard fecal indicators. This statement supports the use of additional alternative fecal indicators to determine recreational water quality in tropical/subtropical regions where considerable monitoring data have already been obtained.

In response to Agenda Question Five, the experts also evaluated the validity of the alternative recreational water quality standards using different fecal indicators. In this regard, alternative recreational water quality standards for freshwater and for coastal marine waters have been developed in Hawaii. However, the numerical standards were based on exceeding ambient concentrations of *C. perfringens* and signaling the presence of sewage contamination. Although these standards have been used in Hawaii to determine when environmental waters are contaminated with sewage, the experts declined to evaluate the credibility of these proposed standards because they were not developed according to EPA guidelines that state the development of numerical recreational water quality standards should be based on measurable health effects.

Results and Recommendations

The most important products of this workshop are the consensus statements. It should be pointed out that the focus of this workshop was to evaluate the problem of appropriate water quality standards in tropical locations, as was described and reported by scientists from Hawaii, Guam, Puerto Rico, and south Florida. Taken together, the consensus statements concur with the previous reports by these scientists that due to environmental sources of fecal indicator bacteria in their respective tropical locations, reliable interpretations of the current recreational water quality standards in tropical locations may be compromised. For these scientists, the consensus statements represent agreements in understanding how environmental factors can control the fate of microorganisms and how these factors can affect water quality standards in tropical environments.

The workshop concluded by identifying overall recommendations and research needs. The statements describing these overall recommendations and research needs are listed below.

1. Conduct more controlled and *in-situ* studies to measure the survival and growth of indicator bacteria under ambient and different climatic conditions.
2. Model the transport of fecal indicator bacteria in soil.
3. From monitoring data, determine the relationships of various fecal indicator microorganisms with pathogens to accurately determine health risks.
4. Meet the needs of a regulator for effective decision-making.
5. Design sound epidemiological studies to understand the indicator-pathogen relationships.
6. Determine the usefulness of the uncertainty analysis approach in microbiological studies.
7. Publish/disseminate research data for the benefit of both scientific and public communities.

Report Addendum

This final report includes an addendum to address two issues that were raised during the review of draft reports and were considered essential for the water agencies representing the governments of the four tropical locations. Since these issues were not discussed during the workshop, they could not be included as part of the proceedings presented in Chapters 1 through 4. As a result, an assessment report of the following two issues is included as an addendum: (1) significance of the findings of this workshop to the water agencies responsible for recreational water quality in Hawaii, Guam, Puerto Rico, and south Florida and (2) recent publications relevant to the findings of this workshop.