American Water Works Association

TECHNOLOGY CONFERENCE PROCEEDINGS

THE LABORATORY'S ROLE IN WATER QUALITY

Presented at the 10th Annual AWWA Water Quality Technology Conference

December 5-8, 1982

PROCEEDINGS

AWWA WATER QUALITY

TECHNOLOGY CONFERENCE

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The Water Quality Division

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FOREWORD

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WQTC OPENING SESSION
PRESIDENT'S ADDRESS

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I'm pleased to welcome you to this 10th Annual Water Quality Technology Conference. I want to commend the Water Quality Division for its fine efforts in sponsoring the Conference. It is an outstanding job of program organization, which clearly addresses major water quality concerns of today.

Because this is the 10th anniversary of our conference, the theme of the opening session is, naturally enough, "A Decade of Progress." I think we all can agree that real progress has been made since 1972.

I'd like to review briefly some of the ways our Association has been involved in this progress... and I'll have a word of a current bit of progress that may result in a bit of special funding for some of you.

Let me approach this by describing our connection with the well-known and highly respected reference book, Standard Methods for the Examination of Water & Wastewater." This book began its long existence in 1905 when the Laboratory Section of the American Public Health Association published the first edition. We joined in 20 years later in 1925 when AWWA and APHA jointly published the sixth edition. Then, in 1947, the Federation of Sewage Works Associations - now known as the Water Pollution Control Federation - helped with the 10th edition. And our three societies have continued to cosponsor production of Standard Methods ever since. We're in the 15th edition now, with work on the 16th well under way.

It takes only a brief comparison of the tables of contents to see how many advances there have been in only the past 10 years, the "Decade of Progress." Automated methods and methods for the analysis of specific organic compounds are only two areas in which significant advances appear. Other people this morning will be discussing this progress in detail.

But let me go back to that 10th edition when the three organizations first worked together. A Joint Editorial Board was organized then to oversee the revisions that result in each new edition. Today the Board is supervising preparation of the 16th edition, which is scheduled for publication in 1984. Each of the three cosponsoring associations appoints the chairman and vice chairman of its standard methods committee to serve on the Joint Editorial Board. For AWWA, these men are Dr. R. Rhodes Trussell of the J. M. Montgomery Engineers in Pasadena, California; and David J. Rexing of Southern Nevada Water System in Boulder, Nevada. The chairman of the Board is Arnold Greenberg of the Department of Health in Berkeley, California.... and I'll tell you in a moment why you should remember his name.

Volunteers do the work on Standard Methods. At present, we have more than 480 people actively involved in preparation of the 16th edition. I'm sure many of you here today are taking part in the effort... and if there are those who have not been assigned, but would like to be, I urge you to get in touch with any of the three men I just named: Trussell, Rexing, or Greenberg.

Now, here's something new. We recognize that more and more of the work in Standard Methods cannot be accomplished free of charge. And consequently, AWWA and the other two sponsoring agencies are making funds available for development of analytical testing methods. The funding will be administered according to guidelines established by the Joint Editorial Board.

Therefore, if you think you'd like to investigate getting in on this funding and contributing to future editions of the book, please make a note to get in touch with Board Chairman Arnold Greenberg.

We are totally committed to the continued improvement of Standard Methods, because it represents the best in current laboratory practices. Each new edition is an important step forward. We depend on your skills as sanitarians, engineers, microbiologists and chemists to keep this most useful publication growing.

Another important area where we'll depend on you is in research. But here we can do a lot for you, too.

I know you're aware that AWWA has restructured and re-emphasized its research effort, but perhaps you haven't heard of a key feature of that effort called "Research Technology Transfer." It's a program that gathers information from people like yourselves who are conducting research on literally any project imaginable. The information is filed in a computer and becomes available to anyone else who needs to know about it.

Here's the interesting part - the only research results we put into this computer are unpublished. You won't find them anywhere else in the world.

Already there are more than 400 separate entries, with more coming in every day. They come from utilities and concern mostly the common problems we all face, such as leak detection, metering, TTHM control and corrósion control. But there are some pretty unusual topics, too, such as using aquatic organisms as indicators of water quality and using compressed gas as fuel for fleet vehicles.

The point is this: If you find yourself approaching a research project and would like to know what others may have done along the same line, get in touch with the AWWA Research Foundation in Denver and let them check the Technology Transfer files for you. In return, we ask that you let the Foundation know what work you're doing and how it comes out. All you have to do is fill out a short one-page form that describes the problem, the solutions tried and the results (good, bad, or indifferent).

Of course, we want your published work, as well as the unpublished activity filed in Technology Transfer's computer. Published material is stored in our new WATERNET data base, which already contains virtually everything printed by AWWA in the past 10 years. This includes articles and technical papers from the JOURNAL, from conferences and seminars, and from research activity sponsored or developed by the Research Foundation. This is the sort of material that is easily overlooked, because the manual retrieval systems we've depended on up to now can't find it in a timely or cost-effective way: WATERNET can.

Rather than try to describe how the system works, let me urge you to get in touch with our Technical Library in Denver. They'll explain how to conduct a one-time search or how to arrange for access to the WATERNET data base anytime from your own terminal, word processor or even home computer.

And now I think we should move along to the rest of this morning's program. Just one last reminder that the exhibit hall is set up for your benefit, so please make use of it. Take the time to discuss your instrument and equipment needs with the suppliers, and learn first-hand about their new products and services.

I hope you'll stop by the AWWA booth, too, and see if any of the publications on display there should be added to your library. There's a good discount for members, so feel free to sign a membership application if you aren't already part of our Association.

And give us the benefit of your opinions about this conference. Do the technical sessions meet your needs? Are the tours worthwhile? Are there topics you'd like to see addressed in the future?

Let us know what you think. We want the WQTC to be one of the foremost elements of advancing water quality analysis, now and in years to come. We need your advice and counsel to make it the best possible conference of its kind.

A DECADE OF PROGRESS IN WATER QUALITY ANALYSIS— STATE LABORATORY MANAGER PERSPECTIVE

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Introduction

During the past 10 years, there have been significant changes in the number and the nature of requests for analytical support received by the Tennessee water quality laboratory. Overall, these changes have presented the laboratory with increasingly difficult challenges to its capabilities, both from the standpoint of the sophistication of the methods required in order to respond effectively to the analytical requests and in the availability of resources needed to carry out the work.

In describing progress achieved during the past decade, the author will begin by briefly discussing the State of Tennessee's water quality laboratory as it existed in 1972 and the social and political influences then operating. He will then discuss the changes in demand which it has experienced since that time and the manner in which the laboratory has responded. Finally, looking into the future, an attempt will be made to predict changes that will occur in the laboratory over the next few years.

The Tennessee water quality laboratory of ten years ago had three components: an organic chemistry section, an inorganic chemistry section, and an aquatic biology section. Organizationally, these sections were under the direction of the Tennessee Department of Public Health (TDPH) Division of Water Quality Control. Drinking water microbiology was, as it still is, tested by the sanitary microbiology section of the Department's clinical microbiologic laboratory, and the aquatic biology section focused its work toward stream monitoring and other pollution control activities. Neither chemistry section distinguished analytically between samples of drinking water and water from other sources.

In 1972, 1358 samples were submitted for inorganic chemical analyses. Of the six chemists involved in water analysis, four were assigned to this area. Atomic absorption spectroscopy was used in the analysis of metals, but the majority of procedures were still wet-bench.

In the same year, 119 samples were received for determination of specific organic contaminants, and two chemists were responsible for this area. Instrumentation included several gas chromatographs, fitted with a variety of detectors: nickel-63 electron capture detectors for chlorinated hydrocarbons, flame ionization detectors for broad response to organics, flame photometric detectors for phosphorus- and sulfur-containing compounds, and a Coulson detector for compounds containing halides and nitrogen. Requests for determination of polychlorinated biphenyls; 2, 4-dichlorophenoxyacetic acid and 2, 4, 5-trichlorophenoxyacetic acid; and pesticides encompassed the entire workload of this area.

As you know, the 1970's were a period of rapidly spreading public awareness of, and concern for, the ways in which society affects the environment. Rachel Carson's Silent Spring, published in 1962, helped foster this awareness, but a number of widely publicized environmental problems provided concrete evidence of the need for a reexamination of mankind's impact on the earth. In the United States, the upswell of citizen involvement was evidenced in the growth of a number of environmentalist groups and dramatically demonstrated in the Earth Day movement of 1970. More importantly, pressures were brought to bear upon the United States congress which resulted in the passage of several pieces of legislation of landmark importance (the National Environmental Policy Act of 1969, the Water Quality Improvement Act of 1970, the Water Pollution Control Act of 1972, and the Safe Drinking Water Act of 1974) and the formation of the Environmental Protection Agency.

Changes in Laboratory Capability

In its capacity as support for the water quality control program, the laboratory has traditionally developed procedures and acquired instrumentation in response to the program's expressed needs for analytical work. Thus, as the Department implemented programs mandated by federal legislation, the laboratory experienced a number of changes in its workload.

The most immediately recognizable change has been in the type of analyses requested. In 1972, as noted above, the Tennessee water quality laboratory received 10 times the number of samples with requests for inorganic chemical determinations as it received with requests for organics analyses. This ratio has now shifted to three samples for inorganic analysis to every two samples to be analyzed for organics.

The change in distribution of sample types has been accompanied by an increase in the absolute volume of samples. This growth has primarily involved the organic chemistry laboratory -- in all other areas of the laboratory, sample volume has remained relatively constant over the decade. The total number of samples submitted for inorganic analyses increased by only approximately 20 percent in the last 10 years. In the organic chemistry laboratory, however, the sample load increased more than 1000 percent in 10 years, 350 percent in the last five. The number of samples received so far in calendar year 1982 is 25 percent greater than last year at this time.

At the same time that the distribution and volume of samples changed, the analytical challenges posed to the laboratory have increased. This change has reflected, in part, a shift towards greater specificity in the requests. Traditional, broad-spectrum analyses which indicated gross levels of contamination, such as the biochemical oxygen demand, chemical oxygen demand, and total organic carbon are less often requested than in the past, but their place has been taken by requests for specific compounds or groups of compounds (e.g., trihalomethanes, priority pollutants).

Another way in which analytical difficulty has increased is in the lower detection limits which have been required of the laboratory. In some instances, where the laboratory previously operated with detection limits in the part per million range -- pesticides in water, for example -- it has achieved minimum detectable concentrations of five to 10 parts per trillion. Smaller improvements in detection level occurred in other analyses, such as metals analysis where a 10-fold concentration provided an additional increment of sensitivity.

The awareness that either chronic or acute exposure to many chemicals potentially present in the environment may represent a threat to health has led to an increased sense of urgency for test results. Although scheduling of work is obviously an important management tool, the assignment of urgent priority to the analysis of samples related to a specific incident can result in the disruption of the flow of work within the laboratory. Understandably, it is necessary that the analytical work in these cases be performed as expeditiously as possible. At the same time, it is important that the assignment of high priority be done judiciously, and that the impact upon the flow of other samples through the laboratory be understood. Recent months have seen a very high level of work submitted with requests for priority treatment. At one time this summer, more than 50 percent of the samples present in the organic section of the Tennessee Department of Public Health's Environmental Laboratory were to be given priority handling.

Clearly, accomodating the changes in demand upon the laboratory has necessitated some technological advances. However, some areas of the laboratory have been affected more than others. In the inorganic chemistry laboratory, most routine analyses currently performed are the same as those carried out ten years ago, with refinement. The advent of graphite furnace methodology facilitated the determination of antimony, arsenic, and selenium. The only other major improvement in technology in the inorganic chemistry laboratory came with the application of Technicon Autoanalyzer methodology to the analysis of phosphate, total kjeldahl nitrogen, ammonia nitrogen, and nitrate and nitrite. Here the result was not a significant improvement in sensitivity or specificity, but rather the conversion of relatively low volume manual procedures into high volume automated analyses without a significant deterioration of the quality of results. These changes, while obviously of great importance to the laboratory in maintaining reasonable turnaround times in the face of increasing workload, have not really revolutionized the practice of inorganic water quality analyses -- more than two-thirds of the procedures performed have not changed appreciably.

The impact of the changes in demand upon the organic chemistry laboratory has been quite different. Although the gas chromatograph remains the basic instrument, and electron capture, flame photometric, and flame ionization detectors continue to be used, many technological improvements have been adopted. In place of the Coulson detector, the more sensitive Hall electrolytic conductivity detector is now used in the analysis of compounds containing halides and nitrogen. In addition, the laboratory now employs the photoionization detector which provides greater sensitivity and diminished interference from lower molecular weight contaminants. Purge and trap methodology, in conjunction with gas chromatography and appropriate detectors, has greatly simplified the analysis of volatile organics; the trihalomethanes being of great importance in drinking water analysis.

Perhaps the greatest advance in the laboratory's organic analytical capability occurred with the acquisition of a gas chromatograph/mass spectrometer/data system in 1975. Although less sensitive than most gas chromatographic determinations, the GC/MS/DS allowed for automated identification of most commonly seen organics due to its computer-based library of 543 mass spectra. With the addition of a purge and trap unit, automated volatile organics mass spectroscopy became possible. With the addition of an acoustic data coupler, or modem, the Tennessee Environmental Laboratory gained the ability to link up with the much larger United States National Institutes of Health/Environmental Protection Agency (EPA) mass spectral data base. The primary deficiency of this system is that once qualitative determinations have been performed, quantitation of any compounds detected must be performed on a gas chromatograph.

A second GC/MS/DS, installed in 1981, not only compensates for the inability of the first unit to quantitate compounds, but possesses additional attributes which make it a superior instrument overall. Its computer-based library of mass spectra includes 31,000 compounds. Tuning of the instrument is through a computer keyboard, rather than by the adjustment of numerous buttons and dials as on its predecessor. Once a quantitiation library is established for each compound of interest, the data system is able to automatically integrate peak areas and compute concentrations. Finally, this instrument has a capillary column rather than the traditional packed column. The analysts find that peak separation and crispness are enhanced and that acid and base/neutral extracts can be combined and run together, resulting in a savings of time.

Another analytical capability acquired by the TDPH Environmental Laboratory during the past decade is high performance liquid chromatography (HPLC). Although called upon less often than gas chromatography or GC/MS, HPLC has proven its worth repeatedly in the analysis of heat-labile compounds and those organics which react with traditional GC column packings.

Regardless of the resources available to the laboratory, it will never be able to justify maintaining instruments capable of performing all possible analyses, particularly where the volume of samples is small. Thus, the availability of reliable reference analytical services is important. The laboratory involved in applying new technology to the tasks at hand is also not likely to be able to make large investments in methods development. When attempting to introduce new methods into the laboratory, the staff may lack sufficient expertise to proceed confidently, or may find the protocol lacking in critical details. Bench training by experienced laboratorians may serve as a good practical introduction to laboratory procedures, but bench supervisors are seldom able to spend the time necessary to cover theory in depth, and generally lack audiovisual and other resources necessary for the most effective presentations.

In each of these areas the State environmental laboratory has found the EPA to be a valuable resource. For example, on a recent occasion when confirmation of the identity of a heat-labile compound was required, EPA Region IV was able to arrange for HPLC/MS analysis. Methods developed or approved by EPA are the basis for all water quality analyses performed in the laboratory. Formal training courses presented by EPA ensured the quality of training received by many of the State's chemists for years, and written procedure manuals and audiovisual materials continue to serve as a reference point in the laboratory. When there are analytical problems with which the laboratory needs assistance, the EPA has always attempted to help.

The increased volume and complexity of requests for analytical support have not resulted solely in the acquisition of more sophisticated instrumentation. Simultaneous with the increasing sophistication of the technology, there has been a move towards formalizing and strengthening quality assurance practices within the State laboratory. Although some of this tightening has been the direct result of the implementation of the Safe Drinking Water Act (SDWA) and the Water Pollution Control Act (WPCA), the laboratory had attempted to document its performance, particularly through calculation of precision, for some time. In administering the SDWA and WPCA, the EPA has provided leadership in formulating thorough guidelines for, and substantive components of, a comprehensive quality assurance program. Performance evaluations and on-site inspections, although serving a regulatory function, respectively also serve as a means of determining accuracy and provide an opportunity for consultation in person. EPA reference samples and analytical standards provide additional gages of accuracy. Guidance on the outlines for standard operating procedure manuals and adequate chain of custody has also come from EPA.

This is not meant to imply that EPA is either the sole authoritative source for information on quality assurance or its only advocate. That there has been widespread acceptance of the need for strong quality assurance programs is attested to in criteria for a comprehensive program (1) and the accompanying editorial (2) published in Analytical Chemistry in 1980. However, the State laboratory must, to the extent that it functions within the regulations promulgated under SDWA and NPDES, comply with the requirements of EPA, and therefore is bound, at a minimum, to follow its lead.

Having accepted primacy under SDWA, there has been an added impact on the laboratory. It now has laboratory certification officers who oversee the quality assurance of municipal and private laboratories within the state. Since the workload in a state the size of Tennessee is insufficient to justify individuals spending full time certifying laboratories, employees responsible for this activity wear several hats. This, however, provides them with an opportunity to meet and interact with other laboratorians and to discuss common problems -- hopefully, providing valuable consultation at the same time.

Over the past decade an additional change has occurred. All environmental media programs have grown in their need for laboratory support. Several set up their own laboratories with overlapping instrumentation. One contracted with the laboratory performing water quality analyses. Each laboratory grew and established its own administrative support system and inventories. In 1980 after careful internal study and external review, all environmentally-related laboratories were placed in a single administrative unit and consolidated with the only other laboratory activity of the health department, the microbiology laboratory. Once that was accomplished, all administrative functions were centralized and a slow process of eliminating duplication was begun. To date, reorganization has allowed reassignment of personnel from areas of low demand to those where significant backlogs existed, and some analytical activities from one area of the laboratory to another. In the future, the laboratory will move from media-specific sections to organization around analytical methods.

Future Changes

Technical changes relating to water quality analysis envisaged for the immediate future in the TDPH Environmental Laboratory include the acquisition of inductively coupled argon plasma atomic excitation spectroscopy (ICAP) capacity, and several automated injectors for use in organic chemistry. ICAP will result in improved detection limits for instrumental analysis of some metals (e.g. uranium, thorium, boron) for which analytical requests are not infrequent. More importantly for the TDPH laboratory, the ability to automate sequential analysis for a battery of metals will be extremely valuable from the standpoint of reduced personnel resources required.

A similar concern motivates the desire for automated injectors to be used with all instrumentation. A limited number of chromatographs currently restricts the flow of work in the organic chemistry laboratory. Rather than attempting to add additional instruments, the alternative of making those instruments on hand more productive seems more appropriate. With autoinjectors in place, a theoretical enhancement of three-fold in productivity is possible.

In the further distant future, some form of personnel accreditation appears probable -- either registration or licensure. The National Sanitation Foundation has begun discussions with interested parties on certification of environmental analytical chemists, and continues study. In an age of rapidly advancing technology and considerable specialization, the best assurance an employer has that a potential employee possesses the skills required to perform competently is certification of a basic educational level, demonstration of specific skills, and proof that the knowledge has been kept up to date. The experience of the medical technologists serves as an example that may be fruitfully studied.

Summary

In summary, the Tennessee water quality laboratory has changed considerably in the past 10 years. The changes have reflected advances in public awareness of, and concern for, potential environmental pollutants. Although there have been improvements in available technology, advances which occurred in quality assurance are equally important. Although it is impossible to predict changes of the distant future reliably, the emphasis in the immediate future would appear to be on improved efficiency and a continued refinement of quality assurance practices.

References

(1) ACS Subcommittee on Environmental Analytical Chemistry. Anal. Chem. 1980, 52, 2442.

(2) Morrison, G.H. Anal. Chem. 1980, 52, 2441.