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Edited by

S. H. JENKINS

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FOREWORD

The 71 papers published in this volume represent those selected by the Programme Committee of the International Association on Water Pollution Research for discussion at the Jerusalem Conference out of the 176 completed papers that were submitted. Attention is drawn to the fact that each of the papers offered was adjudicated by five referees drawn from different countries and their assessments provided the basis of selection. The choice of papers for the Conference was therefore made by a system which is quite as thorough as that used for the selection of papers for the International Association's Journal "Water Research". The International Association would like to take this opportunity of recording its appreciation of the assistance that has been rendered by all the referees in the selection of papers.

In view of the Association's policy to publish in the Proceedings only those papers that were selected for discussion, the referees were also requested to assess the suitability for publication in Water Research of all the papers that were submitted for the Conference. A proportion of those not included in the Conference Proceedings were recommended for publication and some of these, with the consent of the authors, will appear in Water Research in due course.

The International Association on Water Pollution Research is indebted to the publishers, Pergamon Press Ltd., who have made every effort to include authors' last minute alterations to their texts so as to reduce corrections and amendments to papers to a minimum and who have delayed publication of the Proceedings in order to include discussions that were delayed in arrival.

The Israel Host Committee by their efficient organization of the Jerusalem Conference and the provision of editorial office facilities greatly contributed towards the successful presentation and discussion of papers and particularly in the collation of discussions.

In the order in which the sessions were held the Session Chairmen were:- R. Canham, USA., N.E. Cooke, Canada., G.R. Rivas-Mijares, Venezuela., W.J. Weber, USA., S. Arlosoroff, Israel., C.H. Plümer, FRG., L. de W. Henry, Australia., W.H. Wiseley, USA., N.de Baenst, Belgium., R.P. Mathur, India., G.R. Rivas-Majares, Venezuela., F. Josa, Spain., R.D. Sylvester, USA., I. Zohar, Israel., W.A. Murray, South Africa., O. Jaag, Switzerland., G. Jamme, France., A. Wiener, Israel., E. Kuntze, FRG., E. Balasha, Israel., A. Shemtov, Israel., E. Vasseur, Sweden., B. Bergmann-Paulson, Norway., G. Rousse, France., S. Iwai, Japan., J.P. Lagnesse, USA., K.J. Lunn, USA., S. Kishoni, Israel., H.J. Eggink, Netherlands., M. Fleisher, Israel., T.E. Larson, USA., Mrs. O.D. Brockett, New Zealand., A. Sorathesn, Thailand., K. Mudrack, FDR., G. Ainsworth, U.K.,

The Editor's thanks are due to authors and discussors for their acceptance of his amendments to manuscript. He would also like to place on record the appreciation of the International Association on Water Pollution Research to the Upper Tame Main Drainage Authority for the facilities it has provided and to Miss I.M. Herrick for her continued service as editorial secretary.

It is a pleasure to recognise the assistance that has been given by Mr. J. Ian Waddington, Clyde River Purification Board, in compiling the index and to the Chairman of that Board, Councillor D.M. Wardley, J.P., D.L., for permitting the facilities of the Board to be used for the purpose.

In addition to the 71 papers and the discussions that are printed in this volume a further 26 papers were prepared by invitation of the Programme Committee. These papers and all the discussions that resulted from their presentation have been published separately under the title "Management and Pollution Control Problems (Jerusalem Workshop Papers)" as volume 3 of a new series of publications by Pergamon Press Ltd.,

on behalf of the International Association on Water Pollution Research. This new series, "Progress in Water Technology", will in future include the proceedings of Workshop Sessions at the biannual conferences in addition to the proceedings of specialised conferences and books on special subjects written on the invitation of the International Association on Water Pollution Research. Volume 1 in this new series is "Applications of New Concepts of Physical-Chemical Wastewater Treatment (Nashville Conference), and volume 2 is "Phosphorus in Fresh Water and the Marine Environment (London Conference), and volume 4 entitled "Toward a Unified Concept of Biological Waste Treatment (Atlanta City Conference) will appear in 1973.

S.H. Jenkins
Chairman of the Programme Committee
and Executive Editor

ACKNOWLEDGEMENTS

The Israel Host Committee headed by Dr. G. Shelef worked unsparingly to arrange every detail so that the Conference could proceed in a smooth and efficient manner. Special mention must be made of the superb work done by the Conference manager, Mr. G. Rivlin, Director of Kenes-Organisers of Conferences and Special Events Limited together with his devoted assistants Mrs Elana Shapiro and Mrs Katrin Tchechik. Mrs. Ruth Tamar, Conference Secretary, applied her usual skills in helping to see to it that all things were arranged properly and ran smoothly. Many other people contributed actively to the successful organization of the Conference and it would be impossible to mention them all but their efforts are nonetheless fully appreciated and acknowledged.

OPENING ADDRESS TO THE SIXTH INTERNATIONAL CONFERENCE ON WATER POLLUTION RESEARCH

BINYANEI HAOOMA – JERUSALEM – JUNE 19, 1972

PROFESSOR HILLEL I. SHUVAL
Conference President

CHALLENGES FOR THE FUTURE IN WATER QUALITY MANAGEMENT

Since the first Conference of the International Association on Water Pollution Research a decade ago in London, our organization has truly circled the globe, having held conferences in Tokyo, Munich, Prague, San Francisco and Hawaii, and now completing the cycle here in Jerusalem. In many ways this is symbolic since Jerusalem, one of the world's most ancient cities, has struggled to solve problems of water for some three thousand years. Here one can find the remains of marvellous ancient water engineering works side by side with the most modern developments in water technology. Israle is mainly a semi-arid country, but the vision of plentiful flowing water sources has been echoed from the earliest of times. The prophet Isaiah yearned: ". . . for in the wilderness shall water break forth and there shall be streams in the desert . . ." (Isaiah 35, 6).

A few kilometers from this building where we sit today, the water engineers of King Hezekiah some 2,700 years ago, laid out a complex subterranean water supply tunnel dug in solid rock, bringing living water from the Gihon spring into the walled city of Jerusalem. This water supply tunnel functions to this day. The crowning glory of the ancient Israeli water engineers of two thousand years ago was the construction of an intricate system of aqueducts, tunnels and siphons bringing water to the city over a distance of seventy kilometers with some two-hundred thousand cubic meters of capacity in storage reservoirs. Following in this ancient tradition of water engineering, modern Israeli engineers have drilled thousands of wells, built reservoirs and have transported water by aqueduct and pipeline hundreds of kilometers from the Jordan River in the north to the parched deserts of the south, fulfilling the vision of Isaiah of bringing streams of water to the desert – to make it bloom.

The problem that we shall be dealing with at this Conference is the protection and maintenance of the quality of our vital water resources. A paradox of modern technological society is that more and more water is required as populations grow and the standard of living increases, resulting in greater and greater withdrawals from ground and surface sources. With the growing urban and industrial use of water, greater amounts of organic and inorganic wastes are spewed back into the water sources so that less and less pure water becomes available at the quality required as a result of the self-destructive process of pollution.

By the time one of Europe's major rivers, flowing from its sources in the mountains reaches the sea, its entire flow may be almost wholly made up of water used once or more times by upstream cities. Six million people draw upon this river as their main source of water supply. How long may we continue at this pace? Will all of the surface waters of the world eventually face this fate?

Another paradox of our modern technological world is the fact that our society "is hooked" on the use of a vast array of agricultural chemicals and fertilizers to ensure the plentiful food supply for our growing population. But some of these essential chemicals are polluting our water resources or leading to unexpected ecological imbalances. The situation has reached almost crisis dimensions in Israel, a country which is presently utilizing almost all available ground water. Nitrate levels have been increasing at the rate of two milligrams per liter per year for the past fifteen years and today some five hundred wells already show nitrate concentrations equal to or above the standard recommendation for drinking water by the World Health Organization. It appears from research results which will be presented at this Conference by an Israeli scientist, that the very high use of inorganic fertilizers rich in nitrogenous chemicals may be a major factor in this type of ground water pollution. Can we find a solution to this problem which will both provide protection of ground water while maintaining the right level of food production essential to our existence?

Not all water pollution is a result of the disposal of urban and industrial wastes into the environment. The buildup of naturally occurring inorganic salts in the aquifer as a result of incautious water resources management could in some cases provide an extremely serious threat of water pollution, particularly in arid zones. Heavy pumping of ground water coupled with intensive irrigation practises could cause this problem. While substantial amounts of water are lost by evaporation in irrigation practise, the dissolved salts are completely returned to the aquifer resulting in a slow buildup of minerals in the ground water. Here in Israel, this increase amounts to a few miligrams per liter per year. The full impact will be felt only in twenty or even fifty years from now, by which time major portions of our ground water may no longer be suitable for agricultural or domestic use. Do our water quality management programs face up to the severe implications of such creeping water pollution, or will we pass this problem on to the next generation when it may be too late to reverse the process?

It would be a disservice to our profession to imply that we are recklessly riding an uncontrolled path to total pollution of our water resources and that nothing is being done to reverse this trend. At this Conference we shall emphasize not only the new and often ingenious technology developed in our research institutes aimed at overcoming the problems of pollution, but the real accomplishments achieved with the aid of these innovations. Many of the papers to be presented here this week will report on real progress.

An outstanding example is the paper of Gameson and his colleagues of the U.K. They report on the dramatic improvements in the Thames River over the past twenty years. In 1950, a reach of some thirty-five kilometers of the river was at times devoid of oxygen and fish life was extinguished, while today after major investments in modern wastewater treatment, the river is entirely aerobic once again and more than fifty species of fish inhabit this rehabilitated waterway. From the other end of the world, Fujiki of Japan will report later this week that Minamota Bay – once heavily polluted with deadly mercury wastes has been cleaned up by the construction of plants to remove mercury from industrial wastewater and by technological changes in other plants which avoid the use of mercury entirely. Fish caught in the bay in 1961 showed mercury concentrations of 23 mg/kg, more than forty times the concentration considered safe for human consumption. By 1970, only 0.2 mg/kg of mercury was found in the fish of that

once ill-fated bay. This is well within safe limits.

We all rejoice in these historic accomplishments which have been achieved by the co-operative efforts of research scientists and practical engineers who actually went ahead and did the job.

May this Conference serve as a turning-point in the successful campaign to reduce the pollution of our water environment. Let us learn not only to warn of the dangers of uncontrolled pollution, but to point to the successes that can result from the planned and judicious application of our research efforts. Nothing breeds success more than success itself.

With a growing shortage of water in many parts of the world, we will be seeking new sources of water supplies. Can we afford to throw away a vital resource such as water that has been used only once and is still 99.9% pure water? Engineers talk freely of the utilization of seawater, but it is worth noting that seawater contains thirty times more contaminants than municipal wastewater. Israel is one of the few countries in the world that is already utilizing almost all of its ultimate, natural water resources and must look for maximum conservation of its existing supplies. We are already renovating 25% of our urban wastewater for agricultural and industrial purposes. The challenge of the future will be to develop systems to purify wastewater so that they will be safe for unlimited urban use. This issue will be discussed at some length at this Conference.

This international Conference with representatives from thirty-five countries from all continents, from various political, social and economic systems, is symbolic of the role that science and scientists can play in breaking down the barriers of communication that are sometimes artificially placed in our way. The free exchange of ideas is a sine-qua-non for peaceful co-operation of the type that is necessary to assure the proper management of the quality of the world's water resources. Many of the major rivers of the world pass through three or four countries on their twisting path to the sea. Only the most exacting co-operation among the nations sharing the use of the river can guarantee that the maximum benefit can be derived for all concerned. The seas are shared by all nations and here only full international control can prevail in preventing their degradation. May I add that our own region could benefit immeasurably by peaceful co-operation among the nations of the area in developing the limited water resources and to take the measures necessary to prevent their pollution and preserve their quality. May this Conference provide the forum for the meeting of the minds necessary to achieve such true co-operation among nations.

Our profession is called upon to provide scientific answers to the current and future problems involved in preserving the quality of our water. However, technology is not enough. We must guide our administrators and statesmen as to the optimal application of the new technology capable of preventing the deterioration of the environment. On the one hand, insufficient preventive action today may lead to irreversible damage that cannot be corrected at any price in the future. On the other hand, an irrational use of limited financial resources today to achieve unreasonable goals such as a level of absolutely zero pollution as has been recently proposed by some influential ecologists, may lead to a state of disenchantment or even revolt among the public who have so far enthusiastically supported environmental improvement programs. Will they blindly support expenditures to achieve an exaggerated degree of environmental pollution control at the expense of other worthwhile social needs such as housing and education? Concepts

of costs and benefits and maximum social gain must be introduced into our formula for improving the environment.

The task that lies ahead is not an easy one and no single mathematical formula will provide the answer to the complex problems of science and society as far as the management of man's environment is concerned. Here I can only suggest a philosophy which I have found useful in my own career of public service: an eminent British scholar suggested these thoughts as a guideline for the public servant: "Give me the strength and fortitude to change those things which can be changed – the patience and peace of mind not to attempt to change those things that cannot be changed – the good judgement and wisdom to tell one from the other . . ." May this Conference provide us with improved knowledge of how to protect our environment for the betterment of man and the wisdom required to guide ourselves and our leaders on the rational use of this new science and technology so as to achieve the most beneficial social gains for mankind from our efforts.

WHAT PRICE - WATER POLLUTION CONTROL

ABEL WOLMAN

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It is axiomatic that water pollution, in its popular connotation, is sinful. In the climate of public discussion, in the last ten years, the term "pollution" has taken on an absolute character in place of its relative nature. To the specialist, pollution is related to what, where and how. Since water is never static, its ingredients, even without the impact of man and his works, have always been varied. When we speak, therefore, of pollution, it becomes necessary to quantify, to define, and to assess positive and negative values of corresponding methods of abatement.

To the professional, these tasks are complex. To the layman, they are simple – water should be of pristine purity and its ingredients should be zero. The price or the value of these political dicta necessarily places the members of this group in an uncomfortable situation of choosing between supporting the unwise or struggling to maintain the logical. Temptation is always high to bend with the winds of political doctrine, particularly when we have spent a century trying to spark public interest in our discipline. Suddenly, that interest is dominant, even if at times hysterical. Are we then to temper this burst of enthusiasm to re-make the environment in the image of distilled water? The challenge is real. The risk is even greater if that challenge is not discerned and the decision how to meet it is not equally clear. The indecision, so far characteristic of our stance, may result in our being trampled under the charge that we are ecologically immature, are in the eternal business of destroying nature, or are slow in disclosing or implementing sane correctives.

ON OBLIGATIONS

The debate is old as to whether a good end justifies a bad means. Some have recently contended that falsifying scientific data may be justified, if the ultimate purpose is for the common good. The late Leo Szilard has been quoted as suggesting: "don't lie, if you don't have to." De Toqueville, on the other hand, had long maintained that the intellectual's guidance has been very limited in determining public behavior. In general, that behavior has been simplistic, gross and often contradictory.

In such conflicting dilemmas, where should we sit? In my own mind, our position is clear – it is on the side of honesty, logic and wisdom. Our purpose should be to disclose scientific verity, to develop sound technologic implementation, to provide alternative solutions, to clarify choices, and to list tangible and intangible costs and benefits. All of these obligations need to be met to be most useful to society and its political mentors. The politican-statesman, of course, ultimately determines public policy – sometimes wisely and sometimes contrary to the scientists' myopia. Our task remains, however, one of illumination of issues and choices. This has not always been our universal position. The ecologists' contribution has certainly extended the depth and breadth of our horizons, in spite of their tendencies, on occasion, to over-emphasize the evils of science and technology.

This Conference gives us an opportunity to rehearse the considerations which should guide us in making our best contribution to the health and welfare of society. A few months ago, Dr. H. E. Stokinger, in the United States, presented several guidelines for investigators. Parenthetically, Dr. Stokinger is the chief of the Laboratory of Toxicology and Pathology of the National Institute for Occupational Safety and Health, of the United States Department of Health, Education and Welfare. He dignified his suggestions in a series of commandments,* as follows:

"1. Standards must be based on scientific facts, realistically derived, and not on political feasibility, expedience, emotion of the moment, or unsupported information.

"2. All standards, guides, limits and so on, as well as the criteria on which they are based, must be completely documented.

"3. Avoid the establishment of unnecessarily severe standards. This admonishment runs against the current tide of boiling popular enthusiasm for cleaning up pollution completely. But it is time that popular enthusiasm cool down, to recognize the consequences of establishing goals instead of standards.

"4. Determine realistic levels.

"5. Interpret the 'Delaney clause' with informed scientific judgment. This much maligned clause has become an excuse for oncologists to use inappropriate and unrealistically high levels in testing for carcinogenic potential.

"6. Determine trends, not pro tempore monitoring. The most flagrant violations of this commandment are the recommendations . . . regarding mercury . . . One moment's reflection would reveal that the concentration of mercury in the oceans has not changed perceptibly since the white men reached these shores, and that men have eaten these fish and lived and died without signs or symptoms of mercury poisoning. This is not to say that local, aqueous mercury or other excess pollutants should not be spotted, and, when possible, controlled, but that the thoughtless and irrational extension of a local finding to global dimensions is inconceivable in persons of sound mind!

"7. Delimit banning. . . . The banned food additives were either unnecessary or could be readily substituted with less harmful substances. Not so the totally banned DDT† and alkyl mercury compounds. First, DDT does not present an 'imminent hazard' to public health, despite misstatements to the contrary; second, its use for controlling the spread of malaria and African trypanosomiasis is unexcelled, and equivalent substitutes are not available at this time."

To these precepts, other cautions should be recorded. It is unfortunate that rarely are the consequences of decision making so set forth as to make clear, not only monetary costs and benefits, but the far more subtle resultants. Remote and intangible consequences are rarely assessed, because these so often lend themselves to exaggeration both for good and evil results. For example, the purification of water is often in a low cost category, while the processes for waste treatment of very high efficiency are more expensive. Choices between them are too often determined by emotion rather than by reasonably familiar quantitive parameters.

Similarly, threats of economic disaster due to abatement measures and costs are

*H. E. Stokinger. How to Achieve a Realistic Evaluation. Science, 174, 662-665 (November 12, 1971). Jour. American Water Works Association, 64, No. 4 (April 1972).

†The ban has so far been lifted by the Environmental Protection Agency. (A.W.)

perennially debated. Estimates of such debacles vary widely, depending upon who makes them and for what ends. Yet impartial evaluations are increasingly required in order to determine the economic consequences of political action. In this area of activity, our members have a high responsibility for intelligent input, provided they can maintain some kind of intellectual equilibrium in the modern maelstrom of environmental excitement.

The program this week is illustrative of both the positive and the negative contributions of which we speak. The workshops cover wide ranges of significant topics. The public defender, looking over our shoulders, however, might well find it difficult to discover relevance, to determine priority and to evaluate direct and indirect social costs and benefits. One might argue, of course, that these determinations are not within the purview of our assigned purpose or of the disciplines here engaged. The omissions need to be noted, even if perpetuated, because already rumblings regarding the balancing of equities may be detected in various quarters.

In many countries, officials, responsible for public and private expenditures, complain that the lists of research undertakings are not only great in number, but most often lacking in delineation of relative importance or priority. Hundreds of areas of exploration are noted, often with the tacit assumption that all the inquiries are of equal weight and necessity. It is easy to understand why this is so. Every investigator, if he is worth his salt, has his own set of "articles of faith", whether engineer, biologist, chemist, or economist. There should be room, somewhere in this assembly, to debate the merits of short and long range relevance, tangible and intangible costs and benefits, and good and bad externalities.

One of these contradictions is strongly brought to mind as an immediate consequence of the Stockholm meetings. Simply stated, the basic questions are whether pollution is in fact global in nature, whether waters are worse in quality today than 20 years ago, and whether universal monitoring is necessary or not. Are answers to these salient questions part of our deliberations this week? One might raise reasonable doubts as to each of these significant questions. Answers to all of them are already erroneously embedded in the current political literature.

Global pollution, with some important exceptions, is probably not demonstrable. Universal deterioration of waters over past decades is likewise subject to considerable question. Unfortunately, with the exception of recent studies in the United States* and England,** documentation is rare on this score. The studies need to be widely, geographically extended.

Of even greater importance to this group is to engage in a realistic appraisal of the significance of our activities in relation to the problems and policies of the populations of two-thirds of the world. How far, how fast, and how costly are the research findings applicable to developing countries? Is universal implementation desirable and at what price in those countries hungry for moving upward by agricultural and industrial expansions? Are unadjusted standards and goals, now appropriate to developed countries, applicable to the rest of the world? Again, the agenda are relatively bare on these pressing political issues.

*M. Gordon Wolman. The Nation's Rivers. Jour. Water Pollution Control Federation, 44: 5 (May 1972), pp. 715-737. Science, 174: 905 (November 26, 1971).

**Report of a River Pollution Survey of England and Wales, 1970, Volume 1. Her Majesty's Stationery Office, 1971. London, England.

The sheer comprehensiveness of our interests and tasks makes selectivity difficult. It has been said, with some truth, that comprehensiveness of plan stands in the way of quanta of implementation. On a broader scale, in some countries the peculiar situation has developed where action is at least temporarily stalled while waiting for total environmental impact coverage and diagnosis. For developing countries, this restraint is a source of increasing concern.

Even at the risk of sermonizing, this occasion appeared an appropriate one at which to suggest modest undertakings in post-auditing our activities, and in stock-taking of our future objectives and goals. In these days of suspicion of science and technology – in the recent colorful semantics of "the careless technology" – our precepts may well be examined, without indulging in self-flagellation! In so doing, the highly pertinent conclusions reached in the United Nations Conference at Founex, Switzerland, just one year ago, give valuable guidance.

"The major environmental problems of developing countries are essentially of a different kind. They are predominantly problems that reflect the poverty and very lack of development of their societies. . . . In both the towns and in the countryside, not merely 'the quality of life', but life itself is endangered by poor water, housing, sanitation and nutrition, by sickness and disease and by natural disasters."*

The quest for pure water is centuries old. The definition of purity has gone through continuous up-grading, until, in fact, truly tailor-made water is the product. In this practice, social choice has been a dominant factor. The guidance and implementation of such choices remain our primary responsibility.

*Development and Environment. United Nations Conference on the Human Environment. Founex, Switzerland. June 4-12, 1971.

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