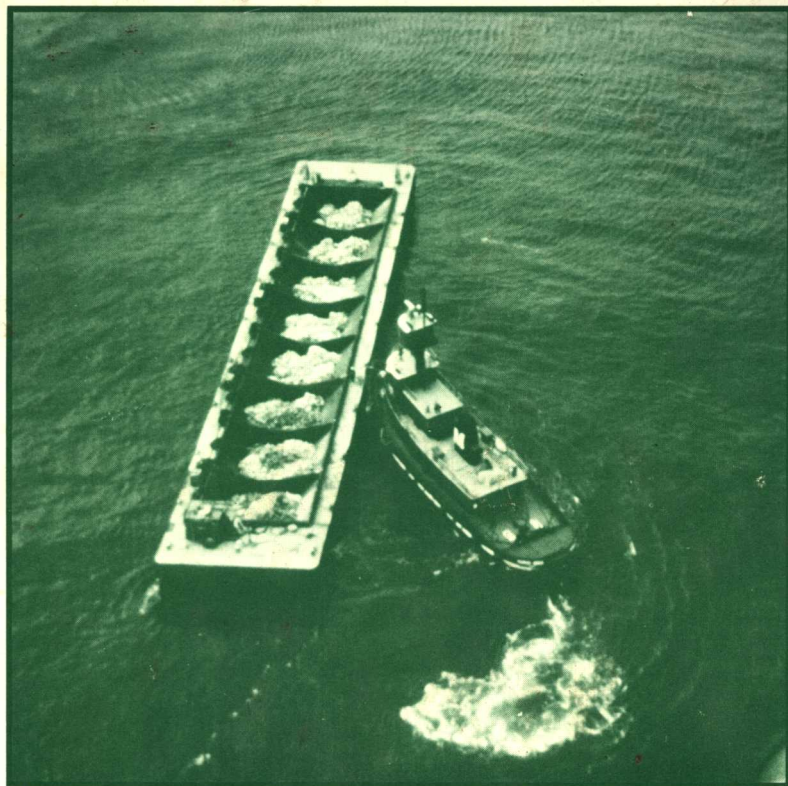


# WASTES IN THE OCEAN



## Volume 1 Industrial and Sewage Wastes in the Ocean

Edited by  
Iver W. Duedall, Bostwick H. Ketchum,  
P. Kilho Park & Dana R. Kester

A Volume in Environmental Science and Technology: A Wiley-Interscience Series of  
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# WASTES IN THE OCEAN Volume 1

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## INDUSTRIAL AND SEWAGE WASTES IN THE OCEAN

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We, the remaining editors, honor

DR. BOSTWICK H. KETCHUM

January 21, 1912-July 15, 1982

who, until his death, had worked for and  
believed in the immortality of  
humanity and science

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# SERIES PREFACE

## Environmental Science and Technology

The Environmental Science and Technology Series of Monographs, Textbooks, and Advances is devoted to the study of the quality of the environment and to the technology of its conservation. Environmental science therefore relates to the chemical, physical, and biological changes in the environment through contamination or modification, to the physical nature and biological behavior of air, water, soil, food, and waste as they are affected by man's agricultural, industrial, and social activities, and to the application of science and technology to the control and improvement of environmental quality.

The deterioration of environmental quality, which began when man first collected into villages and utilized fire, has existed as a serious problem under the ever-increasing impacts of exponentially increasing population and of industrializing society. Environmental contamination of air, water, soil, and food has become a threat to the continued existence of many plant and animal communities of the ecosystem and may ultimately threaten the very survival of the human race.

It seems clear that if we are to preserve for future generations some semblance of the biological order of the world of the past and hope to improve on the deteriorating standards of urban public health, environmental science and technology must quickly come to play a dominant role in designing our social and industrial structure for tomorrow. Scientifically rigorous criteria of environmental quality must be developed. Based in part on these criteria, realistic standards must be established and our technological progress must be tailored to meet them. It is obvious that civilization will continue to require increasing amounts of fuel, transportation, industrial chemicals, fertilizers, pesticides, and countless other products; and that it will continue to produce waste products of all descriptions. What is urgently needed is a total systems approach to modern civilization through which the pooled talents of scientists and engineers, in cooperation with social scientists and the medical profession, can be focused on the development of order and equilibrium in the presently disparate segments of the human environment. Most of the skills and tools that are needed are already in existence. We surely have a right to hope a technology that has created such manifold environmental problems is also capable of solving them. It is our hope that this series in Environmental



Sciences and Technology will not only serve to make this challenge more explicit to the established professionals, but that it also will help to stimulate the student toward the career opportunities in this vital area.

*Robert L. Metcalf*  
*Werner Stumm*

# PREFACE TO *WASTES IN THE OCEAN*

This is the first of six volumes considering the problems of *Wastes in the Ocean* in which we consider the following subjects:

- Volume 1, "Industrial and Sewage Wastes in the Ocean,"
- Volume 2, "Dredged-Material Disposal in the Ocean,"
- Volume 3, "Radioactive Wastes and the Ocean,"
- Volume 4, "Energy Wastes in the Ocean,"
- Volume 5, "Deep-Sea Waste Disposal," and
- Volume 6, "Near-Shore Waste Disposal."

The objectives are to present a comprehensive overview of the state of our knowledge concerning the disposal of waste in the ocean and to present new and original contributions to the evaluation of the impact of the disposal of waste materials on human life and well-being, on the marine biota, on amenities, and on legitimate uses of the ocean. The chapters included in this and succeeding volumes of this series have been subjected to both external and editorial reviews. We are especially grateful to the reviewers of these chapters for the time and effort they devoted to the development of the final manuscripts.

The burgeoning human population on earth and the continuing development of complex industrial technology have inevitably led to enormous increases in both the quantity and the kind of waste material that must be disposed of in ways that do not cause an intolerable degradation of our environment. The optimum solution to the problem is to recycle the waste material in ways that produce a beneficial effect. This is not always possible and various types of treatment can be employed to minimize the quantity of waste and to make the product of the treatment less damaging to our environment. Even after treatment, there will be some residue that must be contained or discharged to the environment.

The options for environmental discharge are limited: on land, into the atmosphere, or into the hydrosphere. Before any one of these particular environments is selected for any specific waste material there should be a careful scientific anal-

ysis of the possible impacts of such a disposal operation. It is hoped that this series will provide the framework for the evaluation of the impact of specific types of waste in the ocean.

From time immemorial people have been disposing of waste materials into the marine environment or into the rivers and streams which ultimately lead to the sea. For millenia it was assumed that the oceans are so vast that our puny efforts would have no measurable or damaging impact. Within the last century it has become clear that some semiconfined bodies of water were being degraded seriously and that the disposal of waste into the hydrosphere must be managed and controlled in order to preserve the integrity of the oceans. We now know that some pollutants are distributed worldwide and can be identified and measured in the waters of the open sea far from the source. The problems associated with ocean disposal of waste material require careful and critical evaluation so that we may assure that the valuable resources of the sea are preserved and protected for future generations. This will require the most careful evaluation of the impact of waste disposal at sea so that we may use the oceans wisely.

We are very thankful to Mr. Treville Leger, Editor, John Wiley & Sons, for his constant encouragement and for being very helpful in the preparation of these volumes.

*The Editors*

# PREFACE

Every year millions of metric tons of industrial wastes and sewage sludges are dumped into the ocean. Scientific research and public debate about the behavior, fate, and effects of these wastes in the sea have increased greatly since 1970. On the global scale, ocean dumping of wastes will probably increase with time. Future dumping will be controlled more rigorously by national laws and international conventions. Application of these laws and conventions will require the understanding, which can be attained through scientific research, of wastes in the ocean.

The decision to dump a particular waste at sea will depend on the economics of disposal, the public perception of its impact, and consideration of environmental effects. In this book, *Industrial and Sewage Wastes in the Ocean*, we are concerned with the latter consideration. We believe that the findings presented here can provide a basis for better informed public perceptions.

This book contains 20 chapters most of which are technical considerations written for scientists. The chapters were organized in seven parts along lines of a theme or discipline, where possible, in order to provide continuity.

The authors provide information on global ocean dumping, the role of U.S. Federal agencies in ocean dumping research, physical oceanographic aspects and chemical effects of ocean dumping, toxic effects of pharmaceutical and other industrial wastes, ocean dumping at the U.S. Mid-Atlantic dumpsites, the role of marine amoebae in sediment, and physical and chemical properties of stabilized coal wastes. The ocean dumping of coal wastes may become an important disposal alternative for populated coastal cities where land is scarce. Scientific strategy on industrial and sewage wastes disposal in the ocean is the main topic of the concluding chapter.

Although this book is not intended to provide a systematic presentation or treatise on all the scientific aspects of ocean dumping, it does reflect the strong and continuing interest in both the theoretical and descriptive studies on the dumping of industrial and sewage wastes. It provides a better understanding of the problems related to the behavior and the effects of these wastes in the sea.

We are grateful to many people who assisted us in the preparation of this book. We express our appreciation to members of the Second International Ocean Disposal Symposium Executive Committee who, in addition to the editors, included Professor Michael A. Champ, Dr. Thomas P. O'Connor, and Dr. Marshall H. Orr.

We thank the reviewers who accepted the arduous task of refereeing the manuscripts. Several people at the Marine Sciences Research Center of the State University of New York at Stony Brook helped significantly in the preparation of the manuscript. We thank Laura Antonacci who patiently retyped most of the chapter manuscripts and maintained organization in the more or less constant communication between authors and editors; Jennifer Jesty who was meticulous in providing editorial assistance and technical comment on each chapter manuscript; Jacqueline Restivo and Mary Ann Lau for technical assistance on a word processor; Marie Gladwish, Marie Eisel, and Vivian Abolins for their care in the touch-up and redrafting of many figures to ensure consistency in illustrations throughout the book; and Anne Lannak, Yong C. Park, and Tom Edwards for doing paste-up and mechanicals, and also for completing countless other tasks. For the photographs on the part title pages we thank W. N. Adams, David Ball, J. M. Brooks, James W. Brown, G. M. Capriulo, Dennis K. Clark, R. R. Colwell, C. E. Firstenberg, G. R. Flierl, Howard R. Gordon, J. C. Hathaway, P. P. Lapennas, W. Y. Lee, J. H. Parker, and F. J. Roethel. This work was supported in part by U.S. National Oceanic and Atmospheric Administration grant 04-8-M01-192.

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*December 1982*

# GLOSSARY OF ACRONYMS

AAS	Atomic absorption spectrophotometry
AODC	Acridine orange direct count
ASTM	American Society for Testing Materials
ATP	Adenosine triphosphate
BLM	U.S. Bureau of Land Management
CEQ	U.S. Council for Environmental Quality
CFA	Continuous flow analyzer
CFU	Colony-forming units
CTD	Conductivity-temperature-depth
DDW	Distilled-deionized water
DMA	<i>N,N</i> -Dimethylaniline
DMRP	U.S. Dredged Material Research Program
DNA	Deoxyribose nucleic acid
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOI	U.S. Department of Interior
DVC	Direct viable counts
EDTA	Ethylenediamine tetraacetic acid
EPA	U.S. Environmental Protection Agency
GC	Gas chromatography
GCMS	Gas chromatography-mass spectrometry
GESAMP	IMCO/FAO/UNESCO/WMO/WHO/IAEA/UN/UNEP <u>J</u> oint <u>G</u> roup of <u>E</u> xperts on the <u>S</u> cientific <u>A</u> spects of <u>M</u> arine <u>P</u> ollution
GEOSECS	Geochemical Ocean Sections Study
HEW	U.S. Department of Health, Education, and Welfare

**xxii    Glossary of Acronyms**

ICOP	Interagency Committee on Ocean Pollution
IMCO	Inter-Governmental Maritime Consultative Organization of United Nations
IUCS	IU Conversion Systems, Inc.
JOIDES	Joint Oceanographic Institutes' Deep Earth Sampling Program
LDC	London Dumping Convention
LORAN	Long Range Navigation
MESA	Marine EcoSystems Analysis
MIBK	Methylisobutylketone
MPRSA	U.S. Marine Protection, Research, and Sanctuaries Act
MS	Mass Spectrometry
NACOA	U.S. National Advisory Committee on Oceans and Atmosphere
NASA	U.S. National Aeronautics and Space Administration
NOAA	U.S. National Oceanic and Atmospheric Administration
NODC	U.S. National Oceanographic Data Center
NSF	U.S. National Science Foundation
NTIS	U.S. National Technical Information Service
OCS	Outer continental shelf
PCB	Polychlorinated biphenyl
PVC	Polyvinyl chloride
SIC	Standard Industrial Classification
SSIE	Smithsonian Science Information Exchange
WHOI	Woods Hole Oceanographic Institution
XBT	Expendable bathythermograph

# CONTENTS

## GLOSSARY OF ACRONYMS

xxi

## PART I INTRODUCTION

1. Global Inputs, Characteristics, and Fates of Ocean-Dumped Industrial and Sewage Wastes: An Overview 3  
*I. W. Duedall, B. H. Ketchum, P. K. Park, and D. R. Kester*
2. Who Is Doing What in Marine Dumping? 47  
*F. T. Manheim*

## PART II PHYSICAL OCEANOGRAPHIC ASPECTS: Modelling and Field Studies

3. Simple Models of Waste Disposal in a Gyre Circulation 69  
*G. R. Flierl*
4. Physical Oceanography Studies Related to Waste Disposal in the Sea 87  
*G. E. B. Kullenberg*
5. Long-Term Mixing Processes in Slopewater 103  
*G. T. Csanady*
6. Dispersion of Particles after Disposal of Industrial and Sewage Wastes 117  
*M. H. Orr and L. Baxter, II*

xvii



**PART III CHEMICAL EFFECTS:**

**Acid-Iron and Pharmaceutical Wastes**

7. Acid-Iron Disposal Experiments in Summer and Winter  
at Deepwater Dumpsite-106 141  
*P. Mukherji and D. R. Kester*
8. Automated Iron Measurements after Acid-Iron Waste  
Disposal 157  
*M. F. Brown, D. R. Kester, and J. M. Dowd*
9. Volatile Organic Wastes at the Puerto  
Rico Dumpsite 171  
*J. M. Brooks, D. A. Wiesenburg, G. Bodennec, and T. C. Sauer, Jr.*

**PART IV BIOLOGICAL AND TOXIC EFFECTS:**

**Pharmaceutical Wastes**

10. Microbial Communities in Surface Waters at the  
Puerto Rico Dumpsite 201  
*F. L. Singleton, J. W. Deming, E. R. Peele, B. Cavari, B. Gunn,  
and R. R. Colwell*
11. Phytoplankton: Comparison of Laboratory Bioassay  
and Field Measurements 219  
*L. S. Murphy, E. M. Haugen, and J. F. Brown*
12. Copepods and Ichthyoplankton: Laboratory Studies  
of Pharmaceutical Waste Toxicity 235  
*W. Y. Lee*
13. Fish: Response to Ocean-Dumped Pharmaceutical  
Wastes 251  
*D. E. Wohlschlag and F. R. Parker, Jr.*

**PART V THE MID-ATLANTIC AND NEW YORK BIGHT DUMPSITES**

14. History of Ocean Disposal in the Mid-Atlantic  
Bight 273  
*W. C. Muir*
15. Effects of Sewage Sludge Dumping on Continental  
Shelf Benthos 293  
*D. W. Lear and M. L. O'Malley*