Industrial Wastewater Management Handbook

HARDAM SINGH AZAD

Industrial Wastewater Management Handbook

HARDAM SINGH AZAD *Editor-in-Chief*
Director, Environmental Projects
NUS Corporation, Rockville, Maryland

McGRAW-HILL BOOK COMPANY

New York St. Louis San Francisco Auckland Bogotá Düsseldorf
Johannesburg London Madrid Mexico Montreal
New Delhi Panama Paris São Paulo Singapore
Sydney Tokyo Toronto

Library of Congress Cataloging in Publication Data
Main entry under title:

Industrial wastewater management handbook.

Includes index.
1. Factory and trade waste—Handbooks, manuals, etc.
2. Water—Pollution—Handbooks, manuals, etc.
3. Sewage—Purification—Handbooks, manuals, etc.
I. Azad, Hardam Singh.
TD897.I44 628'.3 76-17884
ISBN 0-07-002661-0

1234567890 KPKP 785432109876

The editors for this book were Harold B. Crawford and Virginia Anne Fechtmann, the designer was Naomi Auerbach, and the production supervisor was George Oechsner. It was set in Caledonia by Monotype Composition Company, Inc.

Printed and bound by The Kingsport Press.

Industrial Wastewater Management Handbook

OTHER McGRAW-HILL HANDBOOKS OF INTEREST

American Institute of Physics · American Institute of Physics Handbook
American Society of Mechanical Engineers · ASME Handbooks
  Engineering Tables
  Metals Engineering—Design
  Metals Engineering—Processes
  Metals Properties
Baumeister and Marks · Standard Handbook for Mechanical Engineers
Brater and King · Handbook of Hydraulics
Burington · Handbook of Mathematical Tables and Formulas
Burington and May · Handbook of Probability and Statistics with Tables
Callender · Time-Saver Standards for Architectural Design Data
Chow · Handbook of Applied Hydrology
Condon and Odishaw · Handbook of Physics
Conover · Grounds Maintenance Handbook
Crocker and King · Piping Handbook
Croft, Carr, and Watt · American Electricians' Handbook
Davis and Sorensen · Handbook of Applied Hydraulics
DeChiara and Callender · Time-Saver Standards for Building Types
Fink and Carroll · Standard Handbook for Electrical Engineers
Flugge · Handbook of Engineering Mechanics
Hamsher · Communication System Engineering Handbook
Harris · Handbook of Noise Control
Harris and Crede · Shock and Vibration Handbook
Hicks · Standard Handbook of Engineering Calculations
Ireson · Reliability Handbook
Juran · Quality Control Handbook
Karassik, Krutzsch, Fraser, and Messina · Pump Handbook
Korn and Korn · Mathematical Handbook for Scientists and Engineers
LaLonde and Janes · Concrete Engineering Handbook
LeGrand · The New American Machinist's Handbook
Lewis · Management Handbook for Plant Engineers
Lewis and Marron · Facilities and Plant Engineering Handbook
Machol · System Engineering Handbook
Mantell · Engineering Materials Handbook
Maynard · Handbook of Business Administration
Maynard · Industrial Engineering Handbook
Merritt · Building Construction Handbook
Merritt · Standard Handbook for Civil Engineers
Morrow · Maintenance Engineering Handbook
O'Brien · Scheduling Handbook
Perry · Engineering Manual
Raznjevic · Handbook of Thermodynamic Tables and Charts
Rothbart · Mechanical Design and Systems Handbook
Smeaton · Switchgear and Control Handbook
Society of Manufacturing Engineers · Die Design Handbook
Society of Manufacturing Engineers · Tool and Manufacturing Engineers Handbook
Streeter · Handbook of Fluid Dynamics
Stubbs · Handbook of Heavy Construction
Truxal · Control Engineers' Handbook
Tuma · Engineering Mathematics Handbook
Tuma · Handbook of Physical Calculations
Tuma · Technology Mathematics Handbook
Urquhart · Civil Engineering Handbook
Watt and Summers · NFPA Handbook of the National Electrical Code
Woods · Highway Engineering Handbook

To my dear, understanding wife, Jagdesh;
daughter, Ishnella; and son, Jaspaul.

Contributors

OSMAN M. ALY *Manager, Environmental Quality, Campbell Soup Company, Camden, New Jersey (Chapter 5)*

HENRY C. BRAMER *President, Datagraphics, Inc., Carnegie, Pennsylvania (Chapter 9)*

STANLEY J. DEA *Manager, Environmental Process Engineering, NUS Corporation, Rockville, Maryland (Chapter 10)*

DAVIS L. FORD *Senior Vice President, Engineering-Science, Inc., Austin, Texas (Chapter 8)*

LOUIS C. GILDE, JR. *Director, Environmental Engineering, Campbell Soup Company, Camden, New Jersey (Chapter 5)*

MATTHEW GOULD *Corporate Director, Environmental Control, Georgia-Pacific Corporation, Portland, Oregon (Chapter 6)*

LEE HENRY *Director of Laboratories, The Mogul Corporation, Chagrin Falls, Ohio (Chapters 1 and 11)*

JERRY L. JONES *Manager, Environmental Control, Chemical Engineering Group, Stanford Research Institute, Menlo Park, California (Chapter 2)*

WILLIAM A. PARSONS *Director, Corporate Environmental Control, Arthur G. McKee & Company, Cleveland, Ohio (Chapter 7)*

GERRY L. SHELL *President, Gerry Shell Environmental Engineers, Brentwood, Tennessee (Chapter 3)*

J. DONALD WALKER *Chairman and Director of Research and Development, Peabody Welles, Inc., Roscoe, Illinois (Chapter 4)*

JAMES H. WRIGHT *Director, Environmental Systems Department, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania (Chapter 10)*

Foreword

Industrial wastewater management has undergone vast changes since the enactment of PL 92-500 in 1972. Prior to that time, in many cases, industrial wastewater treatment requirements were drawn from domestic wastewater treatment criteria, usually resulting in 85 percent reduction of BOD and suspended solids. Little emphasis was placed on in-plant controls and optimization of end-of-pipe treatment. PL 92-500 has specified criteria of effluent quality for three levels, namely, BPTCA by July 1, 1977, BATEA by July 1, 1983 with a further zero discharge stipulation. BPTCA or Best Practical Technology Currently Available is generally defined as the equivalent of secondary treatment presently being practiced in the particular industrial subcategory. For example, this may be considered as the activated sludge process in the organic chemicals industry. BATEA or Best Available Technology Economically Achievable is generally defined as treatment technology that has been demonstrated on an advanced laboratory or pilot plant scale to be technically and economically feasible for a specific industrial category. Further, new industrial facilities are separately treated under a new source standards category.

Each of these criteria specify the allowable pollutant in pounds per unit production and include pollutants other than the conventional BOD and suspended solids. The permitting procedure specifies both an average effluent quality and a daily maximum.

From what the writer has seen to this point, meeting BPTCA requirements is generally being accomplished by end-of-pipe treatment. It should be recognized that within any industrial subcategory variations in raw waste load may result from differences in plant age and size, raw materials input, output product specifications, and variations in in-plant process operations. For example, in the pulp and paper industry raw waste load will be affected by the type of wood used, the quality and brightness of the bleached product and processing variants such as dry or wet debarking. These factors should be carefully considered in defining effluent limitations under BPTCA so that the treatment technology employed can, in fact, meet the requirements. There is some question at this time whether the BATEA effluent limitations presently being proposed will be changed prior to their implementation. In some cases the economics relative to the additional degree of treatment achieved are very poor. In any event, in most industrial categories attainment of BATEA effluent qualities will be achieved largely by in-plant controls, by-product recovery and recycle. In order to illustrate this point, a detailed study was made by Union Carbide for the Environmental Standards and Water Quality Information Advisory Committee on the economics of meeting BATEA levels. Considering secondary treatment in-place, the annual costs for in-plant waste reduction and effluent filtration was $1.3 million per year to achieve an effluent BOD of 28,000 lbs/day, a suspended solids of 13,800 lbs/day, and a COD of 22,500 lbs/day. If, as an alternative, advanced wastewater treatment employing filtration and activated carbon was added to the present secondary plant, the annual cost would be $4.1 million to achieve an effluent BOD of 25,700 lbs/day, a suspended solids of 9,200 lbs/day, and a COD of 17,850 lbs/day. It is apparent from these numbers that very little improvement in effluent quality is achieved by adding additional end-of-pipe treatment for a significant cost.

In the food processing industry it has been demonstrated that in-plant controls can generally meet BATEA levels at significant savings in cost over advanced end-of-pipe treatment. Consider a plant producing apple juice with a production capacity of 250 tons/day. Utilizing in-plant modifications and controls, the annual cost to meet present BATEA limitations would be $76,000 per year. Employing end-of-pipe treatment technology would result in an annual cost of $105,700. The favorable economics for in-plant controls are obvious. Considering the foregoing comments, the environmental engineer in industry today is faced with a complex problem of developing both a technical and economic solution to water pollution control. A well-defined sampling and monitoring program should be developed with all major sources of wastewater defined. Options for source control, recycle and recovery should be reviewed before consideration of end-of-pipe treatment. Treatment technology should be viewed in light of present and future effluent criteria.

This volume should be of great assistance to the environmental engineer seeking solutions to their problems. The fundamentals relative to establishing available technology and equipment are covered by well-qualified professionals. The experience in six major industrial categories should provide invaluable guidance as to the options available and the results obtainable.

W. WESLEY ECKENFELDER, JR.
Distinguished Professor
Environmental and Water Resources Engineering
Vanderbilt University
Nashville, Tennessee

Preface

Water may be the most reusable and recyclable commodity on earth. Since its supply is limited, we must learn to recycle and reuse it effectively. Different uses of water require different degrees and types of cleanliness. Industry needs water for drinking, steam making, manufacturing operations, cooling, plant and equipment cleaning, fire fighting, gardening, and many specialized purposes. The quality of water required for each of these duties is significantly different.

In today's world, water is not free. In fact, water conveyance and treatment systems cost great sums of money. Then, why turn water into wastewater after only one or two uses? Industrial management is recognizing the benefits of using water for several different duties in descending order of required cleanliness before calling it a waste. This multiple, cascade, or sequential reuse of water minimizes the need for new water supplies. Repeated use or recycle of water for the same duty such as cooling is practiced widely by industry now in reducing its net water consumption and use. In addition to saving water and associated costs, both of these techniques minimize the volume of wastewater that must be treated. A proper combination of these water recycle and reuse methods, coupled with the optimum conveyance and treatment facilities, *may* produce an economical closed-loop, zero discharge system that requires minimum make-up water to function.

"Industrial Wastewater Management Handbook" focuses on the practicality (and sometimes impracticality) of this philosophy. It deals in depth with the water pollution control problems of the six largest water polluting industries. Methods of pollution prevention and product recovery, relative pollution potential of competing manufacturing processes, quantification and characterization of wastewaters at significant sources, practicality and impracticality of zero discharge, and successful industrial wastewater treatment practices have received a major emphasis. Exclusion of other industries and related subjects such as air pollution control and solid wastes management have permitted its distinguished authors to cover the selected subjects in depth and disseminate significant practical data on successful industrial wastewater treatment engineering and management practices.

The chapters on Legislation and Standards, Effluent Discharge Guidelines, Wastewater Monitoring, Wastewater Treatment Technology, and Wastewater Treatment Equipment cover practical fundamentals that apply to all industries. Specific problems, solutions, and case histories of Food, Paper and Allied Products, Chemical, Petroleum, Metals, and Power Generation industries are discussed separately in the second half of the book for optimum industrial coverage. The industrial authors have tried to achieve a proper balance between the traditional manufacturing unit process and end-of-the-pipe wastewater treatment approaches in their problem solving task-force oriented presentations. They first point out how to minimize industrial wastewaters through manufacturing process change, product recovery, water reuse and recycle, stream segregation, and better housecleaning. Then, they show how to develop the most effective, flexible, and economical wastewater treatment schemes for the wastewaters that must be treated prior to discharge or reuse.

This authoritative information is intended to orient the end-of-the-pipe treatment practitioners to wastewater prevention through product recovery and manufacturing process change for cost-effective water pollution control. Many successful industrial wastewater management case histories and other data presented in this book should provide practical guidance to its readers on determining the specific natures of the industrial wastewater problem and on selecting its optimum solution. Practicing engineers, related technical and middle management, students and teachers, regulatory agencies, libraries, and other concerned citizens should find this handbook valuable in achieving a proper understanding of the industrial wastewaters and their judicious management. We encourage and invite constructive comments from our readers so that the future revisions could be improved where possible.

Graham Garratt, book editor of another publishing concern, originally approached Monsanto Enviro-Chem Systems, Inc. in December 1971 to prepare a reference or handbook of this type. Dr. Clinton C. Kemp, then my superior at Monsanto, envisioned the need for such a book and assigned me to develop one. Monsanto Enviro-Chem also allowed Jerry Jones, then its employee, to contribute the chapter on Wastewater Monitoring. When the Editor-in-Chief joined Arthur G. McKee & Co. in mid-1972, William F. Richards and Robert L. Perry (McKee's management) kindly assumed this corporate committment. Bill Richards also

encouraged Dr. William A. Parsons to contribute the chapter on Chemical Industry.

The management of Arthur G. McKee & Company permitted me to devote huge amount of time, paid for many long-distance telephone calls and out-of-town travel, and provided the much needed secretarial assistance for completing most of this handbook. It clearly shows that McKee has excellent professional outlook and very enlightened management. I am grateful to Bill Richards, Bob Perry, Bob Verner and other fine McKee managers for their unforgettable encouragement and material help.

Current affiliations of our contributors indicate major assitance from so many other businesses for this handbook. The McGraw-Hill Book Company, all authors, and I sincerely appreciate this generous industry support.

HARDAM SINGH AZAD, PH.D.

Industrial Wastewater Management Handbook

Section 1

Fundamentals

Contents