# INDUSTRIAL POLLUTION CONTROL

Volume 1: Agro-Industries

E. JOE MIDDLEBROOKS

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A WILEY-INTERSCIENCE PUBLICATION
JOHN WILEY & SONS
New York • Chichester • Brisbane • Toronto

*Library of Congress Cataloging in Publication Data:*

Middlebrooks, E. Joe.
Industrial pollution control.

(Environmental science and technology)
"A Wiley-Interscience publication."
Bibliography: p.
Includes index.
CONTENTS: v. 1. Agro-industries.
1. Pollution. 2. Factory and trade waste—Environmental aspects. 3. Agricultural industries—Environmental aspects. I. Title.
TD194.M5 628.5'4 79-10573
ISBN 0-471-04779-1 (v. 1)

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

# 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 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, fer-

tilizers, 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

For each segment of the agro-industries, this book, which is the first volume of three, presents a general description of the industrial process, the characteristics of the waste products, and the applicable waste treatment methods including the expected performance and cost of the methods. Many good books describing the basic concepts and approaches to solving pollution problems in the industrial sector are available; however, a comprehensive presentation of the agro-industries has not been available till now.

The book is divided into two major parts. Part 1 is a general discussion of the approach to pollution control in the agro-industries and presents an overview of the problems and solutions. Part 2 is divided into 17 sections. Each section describes an individual industrial segment, pollution problems, waste characteristics, treatment techniques, and costs. Part 1 is intended to assist individuals interested in the philosophy and general approach to pollution control in the agro-industries. Part 2 provides the details necessary to make decisions pertaining to preliminary designs and evaluations.

There is considerable similarity among the various segments of the agro-industries, yet the differences are great enough to warrant individual treatments of the 17 segments. All industrial pollution control analyses should be approached as unique problems. This approach invariably yields a superior solution when compared to a generalized analysis. The book is intended to provide the information to make this approach possible.

This volume should meet the needs of many people: the engineer or scientist assigned the task of solving industrial pollution problems; the consulting engineer seeking a solution for an industrial client; the municipal engineer working with waste processing systems treating combined municipal and industrial wastes; the professor teaching an industrial waste processing course; and the state and federal regulatory agencies' personnel involved in the control of industrial pollution, the enforcement of standards, and the manage-

ment of industries planning or operating waste processing facilities. Many users may find more detail than they require for a particular task, and others seeking more detail than is available may consult the reports and papers cited. Regardless of the needs of individuals, however, the book contains specifics or references that should make the task of pollution control easier.

I have made extensive use of many people's work and wish to thank these authors. Credit is given at the point in the text where the borrowed material appears. The contributions of photographs and drawings by equipment manufacturers are gratefully acknowledged. The following companies have made a significant input to this book:

Autotrol Corporation, Milwaukee, Wisconsin
Big Wheels, Inc., Paxton, Illinois
C-E Bauer, Springfield, Ohio
Carborundum Company, Niagara Falls, N.Y.
Envirotech Process Equipment, Salt Lake City, Utah
Foster Wheeler Energy Corporation, Livingston, N.J.
Sharples-Stokes Division, Pennwalt Corp., Warminster, Pa.
SWECO, Inc., Los Angeles, Calif.

The untiring assistance of Kathy Baker, Debby Monke, Janet Hovey, and Becky Jo Hansen in the preparation of the manuscript is greatly appreciated. A special thanks is due Charlotte Middlebrooks for her editing of the text to make it more readable.

When people's contributions to such an extensive task as preparing a book are acknowledged, worthy candidates are unfailingly omitted. I apologize for any omissions and hope to do better the next time.

E. JOE MIDDLEBROOKS

*Logan, Utah*
*August 1979*

# CONTENTS

PART 1

# POLLUTION PROBLEMS IN THE AGRO-INDUSTRIES

## NEED FOR WASTE TREATMENT

### Stream Degradation

When many types of substances are discharged into a receiving body of water, the water quality is degraded to such an extent that beneficial uses are no longer possible. No one industry discharges all types of pollutants, but the discharge of only one substance in sufficient quantity can cause irreparable harm.

### Components with Pollution Potential

Industrial waste discharges contain solids (floating, suspended, settleable, and dissolved), organic matter, nutrients, toxic substances, acids, and alkalies; frequently the discharged water is hot enough to cause temperature changes in the receiving stream.

Floating solids (grease and scum) are unsightly and can affect natural aquatic characteristics such as oxygen transfer and light penetration.

Settleable solids can form sludge blankets which decompose and produce odorous gases and floating mats on the surface of the water body. Blankets of solids also interfere with natural organisms which live attached to the stream bed. Fish hatching is also impeded by settleable solids. Suspended solids detract from the appearance of water and impede light penetration, probably retarding the growth of aquatic vegetation necessary for the survival of other life in the stream or lake. Water treatment for human consumption or other industrial processes is necessary when large concentrations of suspended solids are present.

Organic matter discharged to a watercourse depletes the dissolved oxygen supply in water. The depletion of the dissolved oxygen supply results in a change in the composition of organisms that inhabit a stream. When the dissolved oxygen level drops below approximately 5 mg/l, the more desirable species of fish such as trout and bass leave the area and coarser types predominate. Below an oxygen level of approximately 2 mg/l fish disappear and the environment shifts toward anaerobic species. Only the elimination of the discharge of organic matter or mechanical mixing which increases gas transfer can help the stream to recover from the oxygen-depleted state.

The addition of nutrients such as phosphorus, nitrogen, and trace elements can result in excessive algal growth, and when this growth dies it can exert an oxygen demand which may cause fish kills, as well as unpleasant odors and tastes. Excessive algal growth also interferes with the recreational and domestic uses of a body of water.

Temperature changes in water can produce adverse effects on all aquatic organisms, and the reaeration rate slows with increases in temperature. Fish and other organisms function best within certain temperature limits, and when this optimum range is violated, the organisms move to another location or die. Rapid changes in temperature are extremely dangerous to aquatic life.

Toxic compounds are common constituents of some industrial processes and frequently find their way into streams. Fortunately there are few toxic materials associated with the agro-industries. Where toxic substances are discharged, however, plant and animal life may be affected and the water becomes unsuitable for recreation or human consumption.

Acidity and alkalinity concentrations in wastewater can be critical factors in the quality of a receiving stream. Although not an exact measure of acidity and alkalinity, the pH value is frequently used to measure the effect that a discharge may produce. Effluents from wastewater treatment

plants are usually controlled near neutrality, or a pH value of 7. Wide fluctuations or prolonged changes in the pH value of a receiving stream can be devastating to an aquatic environment.

## Definitions

Many of the terms used throughout this book to describe the characteristics of wastewaters may be unfamiliar to the reader. The following general definitions are presented to assist in studying this segment of the book.

The 5-day, 20°C, biochemical oxygen demand ($BOD_5$) test is widely used to determine the pollutional strength of wastewater in terms of the oxygen required to oxidize or convert the organic matter to a nonputrescible end product. The $BOD_5$ is a bioassay procedure that measures the oxygen consumed by living organisms while utilizing the organic matter present in the wastewater under conditions as similar as possible to those that occur in nature. To make results comparable, the test has been standardized. The $BOD_5$ test is one of the most important in stream pollution control.

Suspended solids are the suspended material that can be removed from wastewaters by laboratory filtration excluding coarse or floating solids that can be screened or settled out readily. Suspended solids are a vital and easily determined measure of pollution and also a measure of the material that may settle out in slow moving streams. Both organic and inorganic materials are measured by the suspended solids test.

Fats, oils, and greases (FOG) are determined by multiple solvent extractions of the filterable portion of a sample of wastewater; therefore, floating oils and greases are not included in the analysis. Several solvents are commonly used and each gives a different result with the same sample. Standardized tests are recommended, but there is much disagreement as to what constitutes the best method. Solvents such as hexane, ether, freon, and carbon tetrachloride are used, and it is important that the solvent be specified. Grease and oil exert an oxygen demand, cause unsightly conditions, and can interfere with anaerobic biological treatment systems.

Acidity, alkalinity, and pH are terms used to express the corrosive or caustic properties of a wastewater. None of the tests related to these properties measures a specific component in a wastewater, but they serve a useful purpose by indicating a relative toxicity to aquatic life.

The chemical oxygen demand (COD) is an alternative to the biochemical oxygen demand ($BOD_5$). It is widely used and measures the quantity of oxygen required to oxidize the materials in wastewater under severe chemical and physical conditions. The major advantage of the COD test is that only a short period (3 hours) is required to conduct the test. The major disadvantage is that the test does not indicate how rapidly the biologically active material would be stabilized in a natural condition.

## Management Philosophy

It is advantageous to consider excess materials as an additional resource to be utilized either in the form discarded or after further processing. This approach to waste processing is economically and environmentally important. If a government or ministry considers protection of the environment and maximum utilization of the base resource important, then the production management and the employees probably have an entirely different attitude toward performing this function and are more likely to take pride in producing high quality effluents and in recovering and utilizing as much of the material as possible. The importance of protecting the quality of the environment and the impact that improper handling of waste materials has on the employees' life styles and the nation as a whole must be emphasized.

Environmental protection must be stressed when management is expected to meet production quotas. Under such production systems management tends to concentrate its talent on product output, if not reminded continually of the value placed on environmental protection by the ministry and the nation. Environmental protection must be considered as a valuable natural resource in the same manner as the labor, materials, and the capital investment required to produce the basic product.

The costs for environmental protection must be paid either now or in the future. The most effective method of handling excess products is to incorporate the facilities for protecting the environment and for further processing of the excess into useful products. It is much less expensive to install such equipment initially than to convert a production process and add pollution control equipment later; moreover, it has proved cheaper to spend today's dollars than inflated ones of a later date. However, it is still less expensive to add to existing systems the facilities for processing excess materials than