HAZARDOUS WASTE PROCESSING TECHNOLOGY

By

YEN-HSIUNG KIANG
AMIR A. METRY

HAZARDOUS WASTE PROCESSING TECHNOLOGY

By

YEN-HSIUNG KIANG
AMIR A. METRY

ANN ARBOR SCIENCE
PUBLISHERS INC / THE BUTTERWORTH GROUP

230 Collingwood, P.O. Box 1425, Ann Arbor, Michigan 48106

Library of Congress Catalog Card Number 81-69070
ISBN 0-250-40411-7

Manufactured in the United States of America

Butterworths, Ltd., Borough Green, Sevenoaks
Kent TN15 8PH, England

PREFACE

The U.S. Environmental Protection Agency (EPA) estimates that in 1980 at least 57 million metric tons of the nation's total waste load could be classified as hazardous. Only 10% of the hazardous wastes are properly managed and disposed. Many dangerous materials that society has thrown away over recent decades have endured in the environment—making household words of "Love Canal" and "Valley of the Drums."

In 1976 Congress passed the Resource Conservation and Recovery Act (RCRA), a law that established a national program to protect human health and the environment from improper handling of solid waste and to encourage conservation of natural resources. Directed by RCRA to take the lead in developing strict controls, EPA issued a national "cradle-to-grave" control system to track all significant quantities of hazardous waste from wherever they are generated to their final disposal.

The "cradle-to-grave" control system classifies hazardous waste activities into five categories: generation, transportation, storage, treatment and disposal. The purpose of this book is to present the state-of-the-art of treatment (or processing) technologies for hazardous wastes. There are two basic processing technologies: thermal and chemical/physical/biological, and one ultimate disposal method—land disposal.

Thermal processing technology is used to destroy organic waste without posing a threat to the environment. Thermal incineration technology is the most advanced and proven technology. A properly designed thermal incineration system will include not only hazardous waste disposal capability, but the possibility of recovering valuable but wasted heat and by-products. Other thermal processing methods are catalytic incineration, wet air oxidation and pyrolysis.

Three kinds of treatment processes can be used to render hazardous waste less hazardous or nonhazardous:

1. physical processes, such as carbon or resin adsorption, centrifuging, flocculation, sedimentation, reverse osmosis, and ultrafiltration;

2. chemical processes, such as fixation, neutralization, ion exchange, oxidation reduction and precipitation; and
3. biological processes, such as activated sludge, composting and land application.

These various options can reduce the degree of hazard and the amounts of waste that must be disposed directly on land, a crucial concern since the land available for disposal is decreasing, while waste tonnages are increasing. Land disposal includes secure chemical landfilling, secure burial and deep well injection. All the above techniques are covered in this book.

This book is divided into two parts. Part 1 discusses the thermal processing technologies, and Part 2 presents treatment and disposal technologies.

Chapter 1 is a general introduction and overview of hazardous waste management and regulations. Chapter 2 is a review of regulations, waste management and technologies governing thermal processes. Also included in Chapter 2 are waste classifications, applicability of processes and process development for system design.

Chapter 3 discusses the evaluation of incineration systems and waste handling technologies. The design of incinerator equipment is discussed in Chapter 4. Chapter 5 deals with special topics involving theory, design, research and development, and instrumentation, control and measurement of incineration systems. The recovery of waste heat and by-products is discussed in Chapter 6. Also presented in Chapter 6 are air and water pollution aspects and treatment. Other thermal processing technologies, such as catalytic incineration, wet air oxidation and pyrolysis are discussed in Chapter 7. The developing technologies—molten salt incinerator and plasma reactor—will also be included. Chapter 8 is an overview of treatment processes and disposal site selection requirements. Chapter 9 is devoted to a discussion of physical treatment processes. Chemical treatment processes are discussed in Chapter 10, and Chapter 11 presents biological treatment processes.

It is the objective of this book to consolidate present state-of-the-art hazardous waste processing technologies into one comprehensive volume. It is hoped that this book will be used as a reference book for professionals involved with hazardous waste activities.

The authors wish to acknowledge the support and encouragement of the Trane Company, IU Conversion Systems Inc. and Roy F. Weston Inc. for their cooperative assistance in typing, duplicating and myriad other tasks associated with the preparation of this work. We thank Ms. Connie Raymond and Ms. Joan McElmoyle for their typing of the

manuscript. We also thank Ms. Louise Miller for her review and technical editing of the manuscript.

The authors wish to express their thanks to the Trane Company, E. I. DuPont DeNemours & Co., Boeing Engineering and Construction Co., Deltak Corporation, Astra Metallurgical Co., Zimpro, TRW Corporation, and Penn Power and Light for their supplying materials to us for preparation of the manuscript.

Yen-Hsiung Kiang
Amir A. Metry

Kiang

Metry

Yen-Hsiung Kiang joined the Trane Company, Process Division, in 1974 as Process Engineer, and is currently Manager of Process Technology, responsible for concept development, process engineering, product and process development, technical consultations, and R&D laboratory operation.

Dr. Kiang received his BSChE from Cheng Kung University, Taiwan, China, and his MS and PhD from the University of Florida, Gainesville. He is also a registered Professional Engineer.

Dr. Kiang is the author of several books and more than 20 articles and other publications covering waste disposal, energy recovery and air pollution control, and has been a lecturer for the APCA Annual Meeting since 1978.

Dr. Kiang has more than seven years of comprehensive experience in the fields of combustion, heat transfer, waste incineration, energy recovery and air pollution control. He is the holder of U.S. Patent No. 4,192,659, "Method for Hot Gas Cooling and Gaseous Contaminant Removal."

Amir A. Metry is currently Vice President, Residuals Management, Roy F. Weston, Inc., West Chester, Pennsylvania. Prior affiliations include Vice President of Research and Systems Engineering, IU Conversion Systems, Inc., Horsham, Pennsylvania; Research Associate, Drexel University; and Project Manager with the firm of Naim Mahfonz, Cairo, Egypt.

Dr. Metry has 18 years of experience in the fields of industrial and hazardous waste and environmental resources management, including process development and design, conceptual engineering, waste disposal facilities siting and design, hazardous waste management, and utility waste management and disposal.

Dr. Metry received his MS and PhD in environmental engineering from Drexel University, and his BS in mechanical engineering and MS in engineering management from Cairo University. He is a member of the American Society of Civil Engineers, National Society of Professional Engineers, the Water Pollution Control Federation and the Institute of Environmental Sciences, and is a diplomate of the American Academy of Environmental Engineers.

Dr. Metry is the author of several books and more than 50 articles in the fields of environmental resources and waste management.

CONTENTS

Part 2
Treatment Technologies

CHAPTER 1

INTRODUCTION AND BACKGROUND

EVERYBODY'S PROBLEM: HAZARDOUS WASTE

Every year, billions of tons of solid wastes are discarded in the United States. These wastes range in nature from common household trash to complex materials in industrial wastes, sewage sludge, agricultural residues, mining refuse and pathological wastes from institutions such as hospitals and laboratories.

The U.S. Environmental Protection Agency (EPA) estimated in 1980 that at least 57 million metric tons of the nation's total wasteload can be classified as hazardous. Unfortunately, many dangerous materials that society has "thrown away" over recent decades have endured in the environment—making household words of 'Love Canal' and 'Valley of the Drums.' These two incidents are not unique. The EPA has on file hundreds of documented cases of damage to life and the environment resulting from the indiscriminate or improper management of hazardous wastes. The vast majority of cases involve pollution of ground water—the source of drinking water for about half of the U.S. population—from improperly sited or operated landfills and surface impoundments (pits, ponds and lagoons). In addition to polluting ground water, the improper handling or disposal of hazardous waste can cause several other kinds of environmental damage, as illustrated by these case histories (often involving more than one form of damage) from EPA records.

Hazardous Waste Can Pollute Ground Water

- The water supplies of Toone and Teague, Tennessee, were contaminated in 1978 with organic compounds when water leached from a nearby landfill. When the landfill closed, about six years earlier, the

site held some 350,000 drums, many of them leaking pesticide wastes. Because the towns no longer have access to uncontaminated ground water, they must pump water in from other locations.

- Ground water in a 30-square-mile area near Denver was contaminated from disposal of pesticide waste in unlined disposal ponds. The waste, from manufacturing activities of the U.S. Army and a chemical company, dates back to the 1943–1957 period. Decontamination, if possible, could take several years and cost as much as $80 million.

Hazardous Waste Can Contaminate Rivers, Lakes, and Other Surface Water

- At least 1500 drums containing waste, primarily from metal-finishing operations, were buried near Byron, Illinois, for an unknown number of years until about 1972. Surface waters (and soil and ground water as well) were contaminated with cyanides, heavy metals, phenols and miscellaneous other materials. Wildlife, stream life and local vegetation were destroyed. The disposal site suffered long-range damage from the toxic pollutants that drained into the soil.
- About 17,000 drums littered a 7-acre site in Kentucky which became known as 'Valley of the Drums.' Some 6000 drums were full, many of them oozing their toxic contents onto the ground. In addition, an undetermined quantity of hazardous waste was buried in drums and subsurface pits. In 1979, EPA analyses of soil and surface water in the drainage area about 25 miles south of Louisville identified about 200 organic chemicals and 30 metals.

Hazardous Waste Can Pollute the Air

- In 1972, waste containing hexachlorobenzene (HCB), one of the family of toxic organic compounds that contains chlorine, was disposed of in a landfill near Darrow and Geismar, Louisiana. The HCB vaporized and subsequently accumulated in cattle over a 100-square-mile area. Some cattle had to be destroyed. This incident represented direct and indirect economic losses of over $380,000. Elevated, although subtoxic, levels of HCB in blood plasma were found in some area residents.
- A truck driver was killed in 1978 as he discharged waste from his truck into one of four open pits at a disposal site in Iberville Parish, Louisiana. He was asphyxiated by hydrogen sulfide produced when liquid wastes mixed in the open pit. The area was surrounded by water and had a history of flooding.