Handbook of SOLID WASTE DISPOSAL

MATERIALS AND ENERGY RECOVERY

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Materials and Energy Recovery

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VAN NOSTRAND REINHOLD ENVIRONMENTAL ENGINEERING SERIES

VAN NOSTRAND REINHOLD COMPANY
New York Cincinnati Toronto London Melbourne

Van Nostrand Reinhold Company Regional Offices:
New York Cincinnati Chicago Millbrae Dallas

Van Nostrand Reinhold Company International Offices
London Toronto Melbourne

Library of Congress Catalog Card Number: 74-26777
ISBN: 0-442-23027-3

Manufactured in the United States of America

Published by Van Nostrand Reinhold Company
450 West 33rd Street, New York, N.Y. 10001

Published simultaneously in Canada by Van Nostrand Reinhold Ltd.

15 14 13 12 11 10 9 8 7 6 5 4 3 2 1

Library of Congress Cataloging in Publication Data

Pavoni, Joseph L.
Handbook of solid waste disposal.

(Van Nostrand Reinhold environmental engineering series)
Includes bibliographies and index.
1. Refuse and refuse disposal. 2. Recycling (Waste, etc.) 3. Refuse as fuel. I. Heer, John E., joint author. II. Hagerty, D. J., joint author III. Title.
TD791.P3 628'.44 74-26777
ISBN 0-442-23027-3

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HANDBOOK OF SOLID WASTE DISPOSAL: MATERIALS AND ENERGY RECOVERY, by Joseph L. Pavoni, John E. Heer, Jr., and D. Joseph Hagerty

Foreword

When Heracles cleaned out the Augean stables by diverting a river from its channel and flushing it through the stalls, the myth does not tell us what he did with the ordure. One hopes that he sent it coursing out over the fields of King Augeas, where, following the orderly rhythms of nature, it became a part of what Homer calls the "all-nourshing earth."

Today, the whole world, over-populated and heavily industrialized, is becoming an Augean stable. The composition of that waste, however, would have overwhelmed the ingenuity even of Heracles. For what could the hero have done with throw-away bottles and cans, bleach containers, spent facial tissues, old refrigerators, and cannibalized automobiles, in addition to human and feedlot wastes?

The sludge made from the garbage the scows of New York City have deposited by the billions of tons outside Ambrose Light has crept back toward the Long Island beaches. Our lakes and rivers are polluted with the detritus of our throw-away economy. Almost too late we are awakening to the nightmare possibility of our teeming world strangling in its own excrement and garbage.

I believe Professors Pavoni, Heer, and Hagerty have given us in their book a vision, rising out of an observed, already functioning technology, of an escape route out of this nightmare. Surveying the whole problem of waste disposal at home and abroad, they have gathered together for the first time all the information that exists about the various futile or promising methods which men employ to put waste out of sight and out of mind.

And to that innate sense of satisfaction which all of us harbor in the idea and practice of frugality, in the art of making something out of nothing, their solution is immensely welcome and heartening. Out of our mountains of rubbish and ordure we can make useful energy. In this exercise, we kill two huge, menacing birds with one stone. What could be more exhilarating?

Here is a meticulously researched, sober and optimistic answer to one of the world's most daunting problems. With the publication of this book, only one

thing remains to do: remember the admonition of St. James (in a somewhat different context): "Be ye doers of the Word, and not hearers only."

MARY BINGHAM

Preface

No book comes to fruition through the efforts of the authors alone, and this manuscript is no exception. Many individuals have guided our efforts and lent us support from the conceptual development of this text through its various stages of editorial revision and production and, although we cannot acknowledge everyone individually, we extend to all our sincere appreciation. At the same time, several persons have given so generously of their time and talent that we would be remiss if we did not recognize them specifically.

Thanks must go to our colleague, John J. Reinhardt, of the Wisconsin Department of Natural Resources for contributing pictures of various solid waste disposal and resource recovery systems throughout the world, and for lending invaluable advice concerning the organization of our study of European solid waste management sites.

We extend deep appreciation to the following European solid waste management professionals who so graciously gave of their time and effort to acquaint us with the solid waste disposal techniques currently being utilized in their countries: Mr. P. K. Patrick of the Greater London Council in London, England; Mr. Pieter Houter of Vuilafvoer Maatschappig in Amsterdam, Holland; Mr. Jacques Sigwalt of Gondard, S.A., in Paris, France; Mr. Hans-Joachim Wallek of Zentraldeponie Emscherbruch in Essen, Germany; and Sig. Squatriti of the Municipality of Rome in Rome, Italy.

The authors wish to acknowledge the assistance of our students, Stephen M. Evans, Roger D. Setters, and Michael S. Evans, in data compilation, and the efforts expended by William H. Sloan and William C. Dues of the University of Louisville in developing illustrations for the text. Grateful thanks are also extended to Sharon Loehr, LeAnne Whitney, Angela Reed, and Judith Pavoni for secretarial assistance, proofreading, and preparation of the index.

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Introduction

In an age of mushrooming technology and scientific innovation, it is ironic that one of man's oldest problems is becoming increasingly acute. The collection and disposal of modern waste products is a monumental task. Moreover, technological change has produced affluent, throwaway societies in many of the industrialized countries of the world. It is becoming apparent that one of the major impacts of technological development is a significant increase in the generation of solid wastes.

Even a quick perusal of life in the United States today indicates that solid waste management is a national problem of considerable magnitude. The severity of this problem caused attention to be focused on the improvement of solid waste management techniques in the early 1960s. This interest spurred the passage of the Solid Waste Disposal Act of 1965 under which research funds became available for the first time from the federal government for basic investigations of solid waste generation and management. Consequently, data regarding waste generation and disposal were gathered during the next several years throughout the United States.

Fig. 1-1 The ever-increasing mountain of solid wastes—a disposal problem requiring an urgent solution (*courtesy* John J. Reinhardt).

In 1970, the Resources Recovery Act was passed by Congress; as a result, the focus of attention was shifted from simple disposal techniques to the development of technology necessary to recover and utilize materials being discarded as waste. During the first two years of this decade many new materials recovery systems were developed in response to this new approach. With the advent of the "energy crisis" in 1973, the focus of attention was again shifted to concentrate on energy recovery systems. Because of technical innovations developed as a result of these actions, and because of conflicting and ambiguous claims made for many of the new so-called "resource recovery" systems, it became apparent that a comprehensive national study of the state-of-the-art of solid waste disposal and resource recovery should be undertaken. This text is the result of a two year state-of-the-art study conducted by the authors at the University of Louisville.

To assess the state-of-the-art of refuse disposal and resource recovery, this particular study was structured to include a survey of scientific and technical literature, a comprehensive series of site visitations, and a number of consultative sessions with recognized experts in the solid waste management field both in the United States and abroad. This three-phase investigation was necessary because of the uncertain state of knowledge concerning many of the innovative disposal and resource recovery methods. Nurtured by the national wave of popular enthusiasm for resource recovery, many schemes and methods have been developed to capitalize on apparently available public funding and support. Almost without exception, these methods have not been objectively and comprehen-

sively evaluated by independent investigators. In many cases, manufacturers' promotional literature is the only source of information available on these new recycling systems. Thus, a major purpose of this study was to establish the feasibility, limitations, and advantages of recently developed methods for materials and energy recovery.

The study on which this text is based was limited to the consideration of disposal techniques and recovery methods. Collection methods were not evaluated for the following reasons:

1. Collection methods as yet have only a secondary influence on resource recovery.
2. Few innovations have been made, to date, in conventional collection techniques.
3. Evaluations of existing collection methods have been accomplished in previous studies by other investigators.

The major emphasis in the evaluation of the systems described in this volume was placed on practicable systems. More time and effort were expended in the study of techniques currently operational or in pilot-plant status than in evaluation of the myriad of systems existent only in designers' after-dinner speeches or preliminary drawings.

The first portion of this book is limited to consideration of systems developed in the United States or widely used in this country. The last portion of the volume is devoted to an examination of European methods and practices.

The information in the following chapters constitutes a state-of-the-art assessment designed to be of primary utility to professionals in the field of solid wastes management and students at an advanced level. For purposes of clarity the presentation has been divided into five main topical areas: conventional disposal operations, innovations in disposal techniques, materials recovery methods, energy recovery systems, and European practice.

1-1. CONVENTIONAL DISPOSAL OPERATIONS

Refuse disposal has been conventionally carried out according to one of three basic methods: sanitary landfill, incineration, or composting. Sanitary landfilling, permanently placing refuse under maximum density in the earth with daily cover, is the predominant method wherever sufficient land is available at low cost near the sources of waste generation.

Where land is not available at economical prices within reasonable distances from the centers of refuse generation, central incineration presents distinct advantages. In fact, because of the small land requirements and apparent weight (and volume) reduction possible with incineration, municipal incineration has been the usual method of refuse disposal in most large cities for several decades.

Despite the ever more stringent air quality standards which are being applied to incinerator effluents and the consequent increasing control costs, incineration still must be considered feasible and economically attractive in many situations. Composting, the aerobic degradation of waste, is not practiced to any significant degree in the United States because of the relative availability of arable land and the abundance of inexpensive fertilizers in North America. With impetus for resource recovery coming from all strata of society, composting may be attempted with more frequency in the future. Certainly aerobic decomposition of degradable waste constituents could be a valuable adjunct to other methods of refuse management.

These conventional disposal techniques are analyzed in-depth in the text since they constitute the bulk of solid waste management methods employed today.

1-2. INNOVATIONS IN DISPOSAL TECHNIQUES

The conventional methods of solid waste disposal have been modified and altered in innumerable ways in individual installations, but only two major innovations appear to offer significant promise. In the first of these innovations, refuse incineration has been modified through combustion controls such as the use of preheated air, the addition of auxiliary fuel, and the modification of combustion chambers to achieve a more complete volume reduction of wastes at much higher operating temperatures. This method has only been implemented on a pilot plant scale to date (1974).

A second major innovation in solid waste disposal, landfill with leachate recirculation, has evolved from the development of leachate management techniques to improve the sanitary landfilling process. The degradation of wastes is accelerated in the landfill during the leachate recirculation process by adding water to the deposited refuse, collecting the generated leachate, adding any necessary conditioners to maximize degradation, and pumping the modified leachate back into the fill. This innovative method also has only been tested in a pilot plant installation to date (1974).

These innovative disposal methods are fully examined in the text to ascertain both the advantages and disadvantages inherent in the operation of these modified disposal techniques.

1-3. MATERIAL RECOVERY OPERATIONS

Materials recovery connotes for many persons in the general public the collection of waste paper "to save trees" and other similar operations which may be simplistic in concept if not impracticable or uneconomical in operation. At the present time, tremendous amounts of materials are recycled on-site or in-house.

For example, industrial scrap is often returned directly to the manufacturing process rather than the waste pile and agricultural residues may be returned to the soil or used for food, raw material, etc. Although vast quantities of industrial process scrap are recycled in-house each year, a large percentage of other goods are wasted and, consequently, there is considerable room for improvement in the recovery of certain types of manufacturing wastes.

Recovery of the materials in mixed municipal wastes appears to be an obvious solution to growing shortages of resources. However, recovery of a potentially valuable material from the solid waste stream is much more difficult than the recovery of homogeneous, uncontaminated manufacturing scrap. Mixing of the constituents in municipal refuse renders some portions of the wastes practically unuseable and, consequently, salvaging these wastes requires expenditures of power and labor in subsequent sorting and separation operations.

Several integrated materials recovery systems have been developed during the last several years to recover materials from mixed municipal refuse including the U.S. Bureau of Mines systems, the wet-pulping method, a combined composting–pyrolysis process, and a new proposed network of materials recovery systems located throughout the United States. These integrated materials recovery systems are described and evaluated.

1-4. ENERGY RECOVERY SYSTEMS

Energy recovery systems are designed to achieve resource conservation through the retrieval of the energy contained in the combustible fraction of the solid waste stream. Much of the combustible portion of solid wastes consists of replaceable or renewable energy-rich materials. Utilization of this energy source in turn decreases the rate of depletion of irreplaceable resources such as coal or oil. This concept is neither unique nor novel since heat recovery has been practiced in European incinerators for more than 30 years. Present developments in the United States include: the installation of the water-tube walls in new heat-recovery incinerators and in the secondary combustion chambers of existing units, the removal and recovery of noncombustibles followed by the burning of the combustible portion of refuse in existing power station boilers, the development of special energy-recovery units designed to operate specifically on refuse, the formulation of pyrolysis systems which are capable of converting refuse to oils, gas, and carbonaceous char, and an anaerobic fermentation process developed to produce natural gas (methane) from solid waste.

With the increasing depletion of currently available energy sources, these new energy recovery systems will probably move to the forefront of solid waste management practice during the next decade. Consequently, each of these systems is analyzed completely and predictions are made concerning their potential for adoption.

1-5. EUROPEAN PRACTICE

The United States' solid waste management practice is compared to European techniques in the final section of the text. This discussion is based on a survey of solid waste disposal and resource recovery facilities in six European countries by the authors in late 1973. Economic, operational, and technical data are presented regarding the following European operations:

1. Power production through waste heat utilization.
2. Composting with front-end and back-end separation.
3. Landfilling to provide recreational areas.
4. Transfer station operations.
5. Animal food production from solid wastes.
6. Paper pulp recovery from solid wastes.

These European solid waste management practices are evaluated for their overall applicability in the United States and recommendations are presented which focus upon the improvement of solid waste disposal and resource recovery system implementation in this country.

1-6. SUMMARY

Refuse disposal and resource recovery methods are undergoing a period of alteration and modification, with rapid development of many small-scale operations for which expansive claims are being made. A comprehensive and critical examination of the state-of-the-art of refuse disposal and resource recovery methodology is urgently needed. The information presented in the following chapters is intended to fulfill, to some extent, this need.