大学环境教育丛书

影印版

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Integrated Solid Waste Management

Engineering Principles and Management Issues

固体废物的全过程管理

—— 工程原理及管理问题

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出 版 前 言

在跨入21世纪之际，面临不断恶化的生存环境，人类清醒地认识到要走可持续发展之路。而发展环境教育是解决环境问题和实施可持续发展战略的根本。高等学校的环境教育，是提高新世纪建设者的环境意识，并向社会输送环境保护专门人才的重要途径。为了反映国外环境类教材的最新内容和编写风格，同时也为了提高学生阅读专业文献和获取信息的能力，我们精选了一些国外优秀的环境类教材，组成大学环境教育丛书(影印版)，本书即为其中的一册。所选教材均在国外被广泛采用，多数已再版，书中不仅介绍了有关概念、原理及技术方法，给出了丰富的数据，还反映了作者不同的学术观点。

我们希望这套丛书能对高等院校师生和广大科技人员有所帮助，同时对我国环境教育的发展作出贡献。

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ABOUT THE AUTHORS

George Tchobanoglous is a professor of civil and environmental engineering at the University of California at Davis. He received a B.S. in civil engineering from the University of the Pacific, an M.S. in sanitary engineering from the University of California at Berkeley, and a Ph.D. in environmental engineering from Stanford University. His principal research interests are in the areas of solid waste management, wastewater treatment, wastewater filtration, aquatic systems for wastewater treatment, and individual on-site treatment systems. He has authored or coauthored over 200 technical publications and 10 textbooks. He is the principal author of the predecessor of this textbook. Unless otherwise noted, all of the photographs in this textbook were taken, developed, and printed by him. Professor Tchobanoglous serves nationally and internationally as a consultant to both governmental agencies and private concerns. An active member of numerous professional societies, he is past president of the Association of Environmental Engineering Professors. He has served as a member of the California Waste Management Board. He is a registered civil engineer in California and a Diplomate of the American Academy of Environmental Engineers.

Hilary Theisen is Vice President and Director of the solid waste and resource recovery program at Brown and Caldwell Consultants. He received a B.S. in civil engineering from the University of Minnesota and an MBA from the University of Santa Clara. His broad solid waste management experience started as a consultant in 1966. In the mid 1970s he directed solid waste operations in Sacramento County, California, which provided collection, transfer, recycling, and disposal services in a community of 380,000 people. At Brown and Caldwell Consultants, he oversees the production of studies, designs, and reports for public agencies and private industry. He has provided consulting services throughout the United States, Argentina, Taiwain, Puerto Rico, and Venezuela. He has authored numerous papers and articles on solid waste management and is the coauthor of the predecessor of this textbook, *Solid Waste: Engineering Principles and Management Issues*. He is a registered professional engineer in California, Hawaii, Oregon, and Washington.

Samuel Vigil is a professor of civil and environmental engineering at California Polytechnic State University, San Luis Obispo. He received a B.S. in civil engineering from the University of California at Berkeley, an M.S. in environmental engineering from Texas A&M University, and a Ph.D. in environmental engineering from the University of California at Davis. His principal research interests are in the areas of gasification of solid wastes, recycling technologies, computer modeling of integrated waste management systems, and computer-aided engineering. He has authored or coauthored 26 publications and holds a U.S. Patent in energy conversion. Professor Vigil is active as a consultant to state and local governments and has also consulted internationally in Europe, Latin America, and Southeast Asia. He is active in the Solid Waste Processing Division of the American Society of Mechanical Engineers, the Air and Waste Management Association, and the American Public Works Association. A Navy veteran, Professor Vigil is a Commander in the Naval Reserve Civil Engineer Corps. He is a registered civil engineer in California and a Diplomate of the American Academy of Environmental Engineers.

PREFACE

Solid wastes are all the wastes arising from human and animal activities that are normally solid and are discarded as useless or unwanted. Because of their intrinsic properties, discarded waste materials are often reusable and may be considered a resource in another setting. *Integrated Solid Waste Management* is the term applied to all of the activities associated with the management of society's waste. The basic goal of Integrated Solid Waste Management is to manage society's waste in a manner that meets public health and environmental concerns and the public's desire to reuse and recycle waste materials.

The need for a text that puts the engineering and scientific details of Integrated Solid Waste Management into the framework of resource management has grown significantly in recent years. This textbook is a response to that need. Both the student and the practitioner will find in this book the engineering principles, the data, the engineering and scientific formulas, and examples of the day-to-day issues associated with the management of municipal solid waste. The book integrates and expands the principles of solid waste management that were introduced in a predecessor text entitled, *Solid Wastes: Engineering Principles and Management Issues*.

ORGANIZATION

This book is organized into six parts. To understand the many facets of solid waste management, it is important to know how the field has evolved from the technology of horse-drawn carts to legislation-driven technology. The historical

development of this field and its current perspectives are presented in Part I. To answer the question of whether solid waste is an untapped resource or a disposal problem, information must be available on the sources, composition, and properties of solid waste. These subjects are considered in Part II.

Because solid waste management has the dual functions of resource recovery and waste disposal, there is no one best place to apply the appropriate technology. In each situation, engineering principles must be applied to evaluate equipment and facility options, to make operational choices, and to develop management systems. The basic engineering principles that are an integral part of solid waste management are presented in Part III.

Advanced engineering principles related to the separation, processing, and transformation of solid waste are presented in Part IV. Separate chapters are included on materials separation and processing technologies, thermal conversion technologies, and biological and chemical conversion technologies. Because the reuse and/or sale of recovered materials is of considerable importance, a separate chapter is devoted to this subject.

The need for continuing care of the land remains after landfills are closed. Closure, restoration, and rehabilitation of landfills are presented in Part V. Both active and abandoned landfill sites are considered as there are thousands of sites that existed before current regulatory standards for closure were developed.

Important management issues that must be evaluated in the development and operation of Integrated Solid Waste Management systems are discussed in Part VI. For many communities, the critical issues arise from state mandates for waste diversion from landfills. Two chapters are devoted to this important topic. The methodology for completing solid waste management plans and documents, mandated by federal and state laws, is considered in the final chapter.

IMPORTANT FEATURES OF THIS BOOK

To illustrate the principles and facilities involved in the field of Integrated Solid Waste Management, over 530 illustrations, graphs, and diagrams are included. To help the reader understand the material presented in this textbook, detailed solved examples and case studies are presented in Chapters 3 through 20. Whenever possible, spreadsheet solutions are presented. To help the readers of this textbook hone their analytical skills, a series of discussion topics and problems are included at the end of each chapter. Selected references are also included at the end of each chapter.

To further increase the utility of this textbook, a series of appendixes have been included. A glossary of terms is presented in Appendix A. Physical characteristics of water and landfill gases are presented in Appendixes B and C, respectively. The statistical analysis of solid waste management data is delineated in Appendix D. Cost data for solid waste equipment and facilities are presented in Appendix E. The remaining appendixes deal with information related to the analysis and design of landfills.

USE OF THIS BOOK

Enough material is presented in this textbook to support up to three quarters or two semester-length courses at either the undergraduate or graduate level. Drafts of this book have been used at both levels at the University of California, Davis, and at the California Polytechnic State University. The first eleven chapters comprise a basic introduction to the field of Integrated Solid Waste Management. In the publisher's outside review process, it was suggested that the material presented in Chapters 12 through 15, which deals with materials recovery and waste transformation, be combined with the material presented in Chapter 9. To have combined these chapters would have altered the basic objective of this textbook. The material presented in Chapters 12 through 20 has been included to allow the book to be used for an advanced course in materials recovery and transformation and for a course dealing with policy issues in integrated solid waste management. A suggested outline for an introductory course in integrated solid waste management is presented below.

Topic	Reading
Introduction and evolution of solid waste management	Chapters 1 and 2
Sources, composition, and properties	Chapters 3, 4, and 5
Solid waste generation rates	Chapter 6
Waste handling, separation, storage, and processing at the source	Chapter 7
Collection of solid waste and source-separated materials	Chapter 8
Separation processing, and transformation of waste materials	Chapter 9
Waste/transfer and transport	Chapter 10
Disposal of solid wastes and residual matter	Chapter 11
Closure of landfills (added for semester course)	Chapter 16
Remedial actions for abandoned waste disposal sites (added for semester course)	Chapter 17
Recycling of waste materials (added for semester course)	Chapter 15

A suggested outline for a graduate course dealing with materials recovery, processing, and waste transformation is presented below.

Topic	Reading
Introduction and evolution of solid waste management	Chapters 1 and 2
Sources, composition, and properties	Chapters 3, 4, and 5
Solid waste generation rates	Chapter 6
Introduction to materials processing	Sections 9-1–9-6
Materials processing and recovery	Chapter 12
Introduction to thermal conversion technologies	Section 9-7
Thermal conversion technologies	Chapter 13
Introduction to biological and chemical conversion technologies	Section 9-8
Biological and chemical conversion technologies	Chapter 14
Recycling of waste materials	Chapter 15
Strategies for selecting the proper mix of technologies	Chapter 18

The following outline is appropriate for a course dealing with integrated solid waste management policy issues.

Topic	Reading
Evolution of waste management and legislation	Chapters 1 and 2
Sources, composition, and properties of solid waste	Chapters 3 and 4
Solid waste generation and collection rates	Chapter 6
Management issues: meeting mandated diversion goals/planning	Chapters 18, 19, and 20
Issues in waste handling, separation, storage, and processing at the source	Readings from Chapter 7
Issues in collection/transfer and transport	Readings from Chapters 8 and 10
Issues in materials recovery	Readings from Chapters 9, 12, and 15
Issues in the disposal of solid wastes and residuals	Readings from Chapter 11
Issues in the closure, restoration, and rehabilitation of landfills	Readings from Chapters 16 and 17
Strategies for selecting the proper mix of technologies	Selected readings

In an undertaking of the magnitude of this textbook, it is impossible to avoid errors. Any corrections, criticisms, or suggestions for improvements will be appreciated by the authors. Additional information and data are also welcomed.

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transfer station operation at San Francisco, CA; The County Sanitation Districts of Los Angeles County, CA; the County of Orange, CA; Escambia County, FL; Oakland Scavengers and Waste Management, Inc.; Yolo County, CA, who allowed us to take photographs at landfills operated under their jurisdiction; and the equipment manufacturers who supplied photographs of equipment and facilities.

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Part VI Solid Waste Management and Planning Issues