Waste Treatment in the Process Industries

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Preface

Environmental managers, engineers, and scientists who have had experience with process industry waste management problems have noted the need for a book that is comprehensive in its scope, directly applicable to daily waste management problems of the industry, and widely acceptable by practicing environmental professionals and educators.

Many standard industrial waste treatment texts adequately cover a few major technologies for conventional in-plant environmental control strategies in the process industry, but no one book, or series of books, focuses on new developments in innovative and alternative technology, design criteria, effluent standards, managerial decision methodology, and regional and global environmental conservation.

This book emphasizes in-depth presentation of environmental pollution sources, waste characteristics, control technologies, management strategies, facility innovations, process alternatives, costs, case histories, effluent standards, and future trends for the process industry, and in-depth presentation of methodologies, technologies, alternatives, regional effects, and global effects of important pollution control practices that may be applied to the industry. This book covers new subjects as much as possible.

Special efforts were made to invite experts to contribute chapters in their own areas of expertise. Since the area of process industry waste treatment is very broad, no one can claim to be an expert in all areas; collective contributions are better than a single author's presentation for a book of this nature.

This book is one of the derivative books of the *Handbook of Industrial and Hazardous Wastes Treatment*, and is to be used as a college textbook as well as a reference book for the process industry professional. It features the major industrial process plants or installations that have significant effects on the environment. Specifically this book includes the following process industry topics: industrial ecology, bioassay, biotechnology, in-plant management, pharmaceutical industry, oil fields, refineries, soap and detergent industry, textile mills, phosphate industry, pulp mills, paper mills, pesticide industry, rubber industry, and power industry. Professors, students, and researchers in environmental, civil, chemical, sanitary, mechanical, and public health engineering and science will find valuable educational materials here. The extensive bibliographies for each type of industrial process waste treatment or practice should be invaluable to environmental managers or researchers who need to trace, follow, duplicate, or improve on a specific process waste treatment practice.

The intention of this book is to provide technical and economical information on the development of the most feasible total environmental control program that can benefit both process industry and local municipalities. Frequently, the most economically feasible methodology is combined industrial-municipal waste treatment.

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Implementation of Industrial Ecology for Industrial Hazardous Waste Management

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1.1 INTRODUCTION

Industrial ecology (IE) is critically reviewed, discussed, analyzed, and summarized in this chapter. Topics covered include: IE definitions, goals, roles, objectives, approach, applications, implementation framework, implementation levels, industrial ecologists' qualifications, and ways and means for analysis and design. The benefits of IE are shown as they relate to sustainable agriculture, industry, and environment, zero emission and zero discharge, hazardous wastes, cleaner production, waste minimization, pollution prevention, design for environment, material substitution, dematerialization, decarbonation, greenhouse gas, process substitution, environmental restoration, and site remediation [1–46]. Case histories using the IE concept have been gathered by the United Nations Industrial Development Organization (UNIDO), Vienna, Austria [39–41]. This chapter presents these case histories to illustrate cleaner production, zero discharge, waste minimization, material substitution, process substitution, and decarbonization.

1.2 DEFINITIONS OF INDUSTRIAL ECOLOGY

Industry, according to the Oxford English Dictionary, is "intelligent or clever working" as well as the particular branches of productive labor. Ecology is the branch of biology that deals with the mutual relations between organisms and their environment. Ecology implies more the webs of natural forces and organisms, their competition and cooperation, and how they live off one another [2–4].

The recent introduction of the term "industrial ecology" stems from its use by Frosch and Gallopoulos [10] in a paper on environmentally favorable strategies for manufacturing. Industrial ecology (IE) is now a branch of systems science for sustainability, or a framework for designing and operating industrial systems as sustainable and interdependent with natural systems. It seeks to balance industrial production and economic performance with an emerging understanding of local and global ecological constraints [10,13,20].

A system is a set of elements inter-relating in a structured way. The elements are perceived as a whole with a common purpose. A system's behavior cannot be predicted simply by analysis of its individual elements. The properties of a system emerge from the interaction of its elements and are distinct from their properties as separate pieces. The behavior of the system results from the interaction of the elements and between the system and its environment (system + environment = a larger system). The definition of the elements and the setting of the system boundaries are "subjective" actions.

In this context, industrial systems apply not only to private sector manufacturing and service, but also to government operations, including provision of infrastructure. A full definition of industrial systems will include service, agricultural, manufacturing, military and civil operations, as well as infrastructure such as landfills, recycling facilities, energy utility plants, water transmission facilities, water treatment plants, sewer systems, wastewater treatment facilities, incinerators, nuclear waste storage facilities, and transportation systems.

An industrial ecologist is an expert who takes a systems view, seeking to integrate and balance the environmental, business, and economic development interests of the industrial systems, and who will treat "sustainability" as a complex, whole systems challenge. The industrial ecologist will work to create comprehensive solutions, often simply integrating separate proven components into holistic design concepts for possible implementation by the clients.

A typical industrial ecology team includes IE partners, associates, and strategic allies qualified in the areas of industrial ecology, eco-industrial parks, economic development, real estate development, finance, urban planning, architecture, engineering, ecology, sustainable agriculture, sustainable industry systems, organizational design, and so on. The core capability of the IE team is the ability to integrate the contributions of these diverse fields into whole systems solutions for business, government agencies, communities, and nations.

1.3 GOAL, ROLE, AND OBJECTIVES

An industrial ecologist's tasks are to interpret and adapt an understanding of the natural system and apply it to the design of man-made systems, in order to achieve a pattern of industrialization that is not only more efficient, but also intrinsically adjusted to the tolerances and characteristics of the natural system. In this way, it will have a built-in insurance against further environmental surprises, because their essential causes will have been designed out [29].

A practical goal of industrial ecology is to lighten the environmental impact per person and per dollar of economic activity, and the role of the industrial ecologist is to find leverage, or opportunities for considerable improvement using practical effort. Industrial ecology can search for leverage wherever it may lie in the chain, from extraction and primary production through final consumption, that is, from cradle to rebirth. In this regard, a performing industrial ecologist may become a preserver when achieving endless reincarnations of materials [3].

An overarching goal of IE is the establishment of an industrial system that recycles virtually all of the materials. It uses and releases a minimal amount of waste to the environment. The industrial systems' developmental path follows an orderly progression from Type I, to Type II, and finally to Type III industrial systems, as follows:

1. Type I industrial systems represent an initial stage requiring a high throughput of energy and materials to function, and exhibit little or no resource recovery. It is a once flow-through system with rudimentary end-of-pipe pollution controls.