ENVIRONMENTAL ENGINEERING

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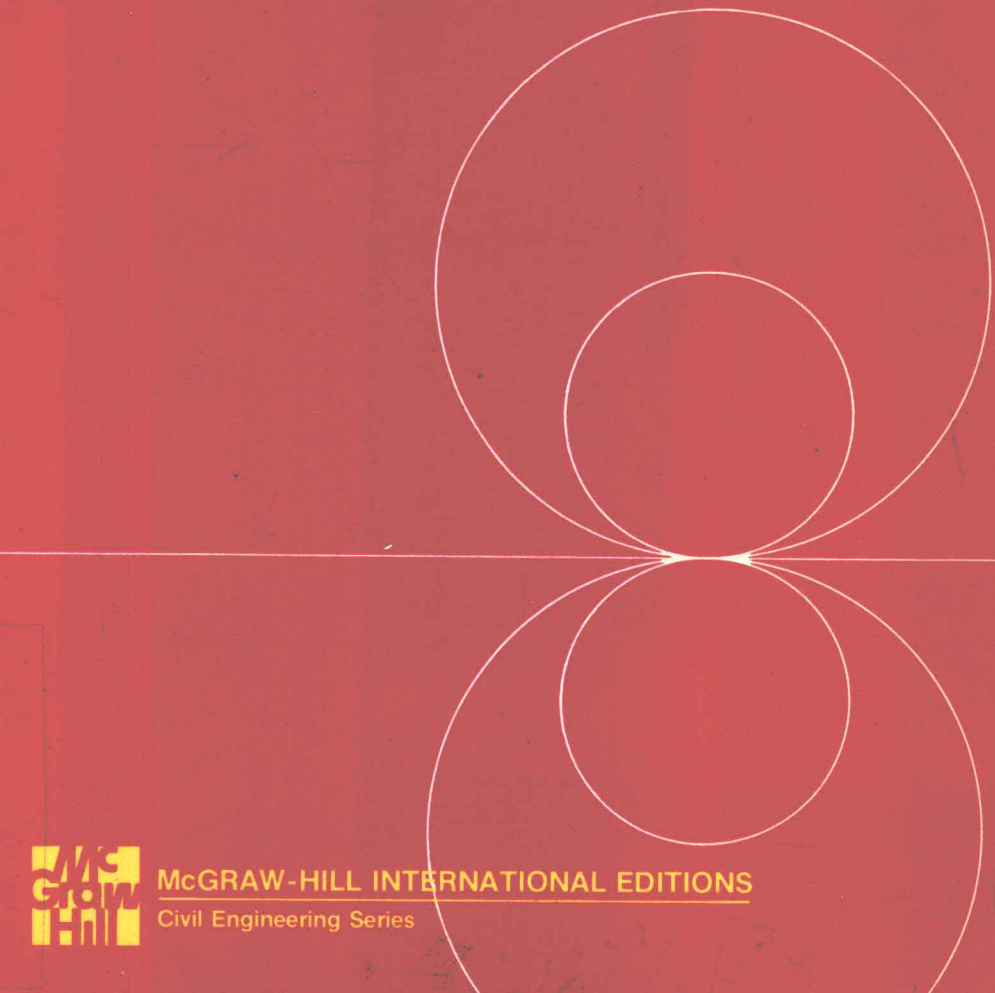

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ENVIRONMENTAL ENGINEERING

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PREFACE

Engineers and scientists from a number of related disciplines have been involved in the development of an academic basis for the understanding and management of the environment. The management of water quality has been dealt with in microbiology and sanitary engineering courses; air pollution problems have been covered in chemical and/or mechanical engineering courses; and the management of solid waste, long neglected by academicians, has been chiefly the purvey of those directly responsible for hauling and disposal operations.

During the last 10 to 13 years, schools of engineering have made considerable progress toward bringing the principles drawn from many related academic disciplines together and unifying them under the title *environmental engineering*. Not surprisingly, texts in this relatively new subject area have developed along classical, separatist lines. Thus, there have been a number of texts featuring in-depth treatment of one specific area (i.e., water, air, solid waste) and few texts attempting to treat the subject of environmental engineering as a whole.

The purpose of *Environmental Engineering* is to bring together and integrate in a single text the more general subject matter of the three principal areas of environmental engineering—water, air, and solid-waste management. And, as Chap. 1 indicates, this integration goes beyond binding three texts in a single cover.

Environmental Engineering introduces a unique approach to the overall concept of environmental engineering, an approach that emphasizes the relationship between the principles observed in natural purification processes and those employeed in engineered processes. First, the physical, chemical, mathematical, and biological principles of defining, quantifying, and measuring environmental quality are described. Next, the processes by which nature assimilates waste material are discussed and the natural purification processes that form the bases of engineered systems are detailed. Finally, the engineering principles and practices involved in the design and operation of conventional environmental engineering works are covered at length.

The breadth and depth of the material in this book precludes complete coverage in a one-semster or one-quarter course. However, the arrangement of the material lends itself to several different course formats.

1. For introductory engineering courses at the sophomore or junior level, Chaps. 1, 2, 3, 7, 8, and 10 provide an overview of the principles involved in environmental engineering systems. These chapters assume a basic knowledge of chemistry, biology, physics, and mathematics. However, because many engineering curricula contain few chemistry and even fewer biology or microbiology courses, the chapters review these subjects in detail. The introductory sections of Chaps. 4, 5, 9, 11, and 12 may be utilized to add relevance to the theoretical discussions. A course following this format will satisfy ABET requirements for engineering science.
2. If the first approach is used for an introductory course, the remaining chapters (4, 5, 6, 9, 11, and 12) can be used as a follow-up course in environmental engineering design. This course should be restricted to engineering students at the junior or senior level who have completed basic fluid mechanics. Such a course would meet ABET's engineering design criteria.
3. A more classical approach would be to use the first six chapters as a text for a one-semester or one-quarter course in water and wastewater engineering. A second one-semester/quarter course on air-pollution control and solid-waste management would use Chaps. 7 through 12. Designed for junior- or senior-level engineering students that have completed basic fluid mechanics, these two courses will meet ABET criteria for engineering design and science, or an approximate one to one ratio.
4. Chapters 1, 2, 3, 7, 8, and 10 can also be used for a companion course in environmental science for nonengineering students, provided allowance is made for the limited mathematical background of the students.

Whatever the approach used, the text should leave students with a clear understanding of the principles of all three of the major areas of enviromental engineering. User comments and suggestions concerning the effectiveness of this approach would be greatly appreciated.

The authors wish to acknowledge the fact that development and publication of *Environmental Engineering* would not have been possible without the help and inspiration of our former professors, the challenge and motivation of our students, the assistance and encouragement of our colleagues, the patience and forebearance of our editors, and the support and understanding of our families.

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Donald R. Rowe
George Tchobanoglous

ENVIRONMENTAL ENGINEERING

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ONE

INTRODUCTION

Environmental engineering has been defined as the branch of engineering that is concerned with protecting the environment from the potentially deleterious effects of human activity, protecting human populations from the effects of adverse environmental factors, and improving environmental quality for human health and well-being. [1-2]

As the above definition implies, humans interact with their environment—sometimes adversely impacting the environment and sometimes being adversely impacted by pollutants in the environment. An understanding of the nature of the environment and of human interaction with it is a necessary prerequisite to understanding the work of the environmental engineer.

1-1 THE ENVIRONMENT

Simply stated, the environment can be defined as one's surroundings. In terms of the environmental engineer's involvement, however, a more specific definition is needed. To the environmental engineer, the word *environment* may take on global dimensions, may refer to a very localized area in which a specific problem must be addressed, or may, in the case of contained environments, refer to a small volume of liquid, gaseous, or solid materials within a treatment plant reactor.

The global environment consists of the atmosphere, the hydrosphere, and the lithosphere in which the life-sustaining resources of the earth are contained. The *atmosphere*, a mixture of gases extending outward from the surface of the earth, evolved from elements of the earth that were gasified during its formation and metamorphosis. The *hydrosphere* consists of the oceans, the lakes and streams, and the shallow groundwater bodies that interflow with the surface water. The *lithosphere* is the soil mantle that wraps the core of the earth.

The *biosphere*, a thin shell that encapsulates the earth, is made up of the atmosphere and lithosphere adjacent to the surface of the earth, together with the