HANDBOOK OF ENVIRONMENTAL ENGINEERING VOLUME 7

Biosolids Engineering and Management

Edited by

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The Editors of the Handbook of Environmental Engineering series dedicate this volume and all subsequent volumes to Thomas L. Lanigan (1938–2006), the founder and President of Humana Press, who encourged and vigorously supported the editors and many contributors around the world to embark on this ambitious, life-long handbook project (1978–2009) for the sole purpose of protecting our environment, in turn, benefiting our entire mankind.

Preface

The past thirty years have seen a growing desire worldwide that positive actions be taken to restore and protect the environment from the degrading effects of all forms of pollution—air, water, soil, and noise. Since pollution is a direct or indirect consequence of waste, the seemingly idealistic demand for "zero discharge" can be construed as an unrealistic demand for zero waste. However, as long as waste continues to exist, we can only attempt to abate the subsequent pollution by converting it to a less noxious form. Three major questions usually arise when a particular type of pollution has been identified: (1) How serious is the pollution? (2) Is the technology to abate it available? (3) Do the costs of abatement justify the degree of abatement achieved? This book is one of the volumes of the *Handbook of Environmental Engineering* series. The principal intention of this series is to help readers formulate answers to the above three questions.

The traditional approach of applying tried-and-true solutions to specific pollution problems has been a major contributor to the success of environmental engineering and has accounted in large measure for the establishment of a "methodology of pollution control." However, the realization of the ever-increasing complexity and interrelated nature of current environmental problems renders it imperative that intelligent planning of pollution abatement systems be undertaken. Prerequisite to such planning is an understanding of the performance, potential, and limitations of the various methods of pollution abatement available for environmental scientists and engineers. This series of handbooks reviews at a tutorial level a broad spectrum of engineering systems (processes, operations, and methods) currently being utilized, or of potential utility, for pollution abatement. We believe that the unified interdisciplinary approach presented in these handbooks is a logical step in the evolution of environmental engineering.

Discussion of the various engineering systems presented shows how an engineering formulation of the subject flows naturally from the fundamental principles and theories of chemistry, microbiology, physics, and mathematics. This emphasis on fundamental science recognizes that engineering practice has in recent years become more firmly based on scientific principles rather than on its earlier dependency on empirical accumulation of facts. It is not intended, though, to neglect empiricism where such data lead quickly to the most economic design; certain engineering systems are not readily amenable to fundamental scientific analysis, and in these instances we have resorted to less science in favor of more art and empiricism.

Since an environmental engineer must understand science within the context of application, we first present the development of the scientific basis of a particular subject, followed by exposition of the pertinent design concepts and operations, and detailed explanations of their applications to environmental

quality control or remediation. Throughout the series, methods of practical design and calculation are illustrated by numerical examples. These examples clearly demonstrate how organized, analytical reasoning leads to the most direct and clear solutions. Wherever possible, pertinent cost data have been provided.

Our treatment of pollution-abatement engineering is offered in the belief that the trained engineer should more firmly understand fundamental principles, be more aware of the similarities and differences among many of the engineering systems, and exhibit greater flexibility and originality in the definition and innovative solution of environmental pollution problems. In short, the environmental engineer should by conviction and practice be more readily adaptable to change and progress.

Coverage of the unusually broad field of environmental engineering has demanded an expertise that could only be provided through multiple authors. The authors use their customary personal style in organizing and presenting their topics; consequently, the topics are not discussed in a homogeneous manner. Moreover, owing to limitations of space, some of the authors' topics could not be discussed in great detail, and many less important topics had to be merely mentioned or commented on briefly. All authors have provided an excellent list of references at the end of each chapter for the benefit of the interested readers. As each chapter is meant to be self-contained, some mild repetition among the various texts was unavoidable. In each case, all omissions or repetitions are the responsibility of the editors and not the individual authors. With the current trend toward metrication, the question of using a consistent system of units has been a problem. Wherever possible, the authors have used the British system (fps) along with the metric equivalent (mks, cgs, or SIU) or vice versa. Conversion factors for environmental engineers are attached as an appendix in this handbook for the convenience of international readers. The editors sincerely hope that this duplication of units will prove to be useful to the reader.

The goals of the *Handbook of Environmental Engineering* series are (1) to cover entire environmental fields, including air and noise pollution control, solid waste processing and resource recovery, physicochemical treatment processes, biological treatment processes, biosolids management, water resources, natural control processes, radioactive waste disposal, and thermal pollution control; and (2) to employ a multimedia approach to environmental pollution control since air, water, soil, and energy are all interrelated.

As can be seen from the above handbook coverage, no consideration is given to pollution by type of industry, or to the abatement of specific pollutants. Rather, the organization of the handbook series has been based on the three basic forms in which pollutants and waste are manifested: gas, solid, and liquid. In addition, noise pollution control is included in the handbook series.

This book, volume 7, *Biosolids Engineering and Management*, is a sister book to volume 6, *Biosolids Treatment Processes.* Both biosolids books have been designed to serve as basic biosolids treatment textbooks as well as comprehensive reference books. We hope and expect they will prove of equally high value to advanced undergraduate and graduate students, to designers of wastewater,

biosolids, and sludge treatment systems, and to scientists and researchers. The editors welcome comments from readers in all of these categories. It is our hope that both books will not only provide information on the physical, chemical, and biological treatment technologies, but also serve as a basis for advanced study or specialized investigation of the theory and practice of individual biosolids management systems.

This book (Volume 7) covers the topics of sludge and biosolids transport, pumping and storage, sludge conversion to biosolids, waste chlorination for stabilization, regulatory requirements, cost estimation, beneficial utilization, agricultural land application, biosolids landfill engineering, ocean disposal technology assessment, combustion and incineration, and process selection for biosolids management systems. The sister book (Volume 6) covers topics on biosolids characteristics and quantity, gravity thickening, flotation thickening, centrifugation, anaerobic digestion, aerobic digestion, lime stabilization, low-temperature thermal processes, high-temperature thermal processes, chemical conditioning, stabilization, elutriation, polymer conditioning, drying, belt filter, composting, vertical shaft digestion, flotation, biofiltration, pressurized ozonation, evaporation, pressure filtration, vacuum filtration, anaerobic lagoons, vermicomposting, irradiation, and land application.

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