Handbook of Environmental Engineering 20

Lawrence K. Wang
Mu-Hao Sung Wang
Yung-Tse Hung
Nazih K. Shammas *Editors*

Integrated Natural Resources Management

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Handbook of Environmental Engineering

Volume 20

Series Editors

Lawrence K. Wang
PhD., Rutgers University, New Brunswick, NJ, USA
MS, University of Rhode Island, Kingston, RI, USA
MSCE, University of Missouri, Rolla, MO, USA
BSCE, National Cheng Kung University, Tainan, Taiwan, ROC

Mu-Hao Sung Wang
PhD., Rutgers University, New Brunswick, NJ, USA
MS, University of Rhode Island, Kingston, RI, USA
BSCE, National Cheng Kung University, Tainan, Taiwan, ROC

The past 30 years have seen the emergence of a growing desire worldwide to take positive actions to restore and protect the environment from the degrading effects of all forms of pollution: air, noise, solid waste, and water. The principle intention of the Handbook of Environmental Engineering (HEE) series is to help readers formulate answers to the fundamental questions facing pollution in the modern era, mainly, how serious is pollution and is the technology needed to abate it not only available, but feasible. Cutting-edge and highly practical, HEE offers educators, students, and engineers a strong grounding in the principles of Environmental Engineering, as well as providing effective methods for developing optimal abatement technologies at costs that are fully justified by the degree of abatement achieved. With an emphasis on using the Best Available Technologies, the authors of these volumes present the necessary engineering protocols derived from the fundamental principles of chemistry, physics, and mathematics, making these volumes a must have for environmental pollution researchers.

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Lawrence K. Wang • Mu-Hao Sung Wang
Yung-Tse Hung • Nazih K. Shammas
Editors

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Editors
Lawrence K. Wang
Lenox Institute of Water Technology
Lenox, MA and Newtonville, NY, USA

Mu-Hao Sung Wang
Lenox Institute of Water Technology
Lenox, MA and Newtonville, NY, USA

Yung-Tse Hung
Department of Civil and Environmental Engineering, Cleveland State University
Cleveland, OH, USA

Nazih K. Shammas
Lenox Institute of Water Technology and Krofta Engineering Corporation
Lenox, MA and Newtonville, NY, USA

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Preface

The past seventy-five years have seen the emergence of 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, thermal, radioactive, 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 are the environmental pollution and water resources crisis? (2) Is the technology to abate them available? and (3) Do the costs of abatement justify the degree of abatement achieved for environmental protection and natural resources conservation? 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 environmental and water resources problems has been a major contributing factor 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 pollution control 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 environmental protection available for environmental scientists and engineers. In this series of handbooks, we will review at a tutorial level a broad spectrum of engineering systems (natural environment, processes, operations, and methods) currently being utilized, or of potential utility, for pollution abatement, environmental protection, and natural resources conservation. We believe that the unified interdisciplinary approach presented in these handbooks is a logical step in the evolution of environmental engineering.

Treatment of the various engineering systems presented will show 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 natural resources engineer must understand science within the context of applications, 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 natural resources conservation or environmental protection. Throughout the series, methods of mathematical modeling, system analysis, 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 or models have been provided.

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

Coverage of the unusually broad field of environmental natural resources engineering has demanded an expertise that could only be provided through multiple authorships. Each author (or group of authors) was permitted to employ, within reasonable limits, the customary personal style in organizing and presenting a particular subject area; consequently, it has been difficult to treat all subject materials in a homogeneous manner. Moreover, owing to limitations of space, some of the authors' favored topics could not be treated 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. The editors sincerely hope that this redundancy of units' usage will prove to be useful rather than being disruptive to the readers.

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, biotechnology, biosolids management, flotation technology, membrane technology, desalination technology, water resources, natural control processes, radioactive waste disposal, hazardous waste management, and thermal pollution control; and (2) to employ a multimedia approach to environmental conservation and protection since air, water, soil, and energy are all interrelated.

This book (Volume 20, Integrated Natural Resources Management) and its two current sister books (Volume 17, Natural Resources and Control Processes and Volume 19, Environmental and Natural Resources Engineering) of the *Handbook of Environmental Engineering* series have been designed to serve as natural resources engineering reference books as well as supplemental textbooks. We hope and expect they will prove of equal high value to advanced undergraduate and graduate students, to designers of natural resources systems, and to scientists and researchers. The editors welcome comments from readers in all of these categories. It is our hope that the three natural resources engineering books will not only provide information on natural resources engineering, but also serve as a basis for advanced study or specialized investigation of the theory and analysis of various natural resources systems. The third sister book, *Integrated Natural Resources Research*, is now in the planning stage.

This book *Integrated Natural Resources Management* (Volume 20) covers the topics on the effect of global warming and climate change on glaciers and salmons; village-driven latrines with "engineers without borders – USA"; analysis for surface water quality management; treatment of electrical and electronic components manufacturing wastes; water quality control of tidal rivers and estuaries; geographic information systems and remote sensing applications in environmental and resources engineering; investigation and management of water losses from wet infrastructure; lake restoration and acidic water control; biohydrogen production through mixed culture dark anaerobic fermentation of industrial waste; agricultural wastes–derived adsorbents for decontamination of heavy metals; removal of heavy metal ions using magnetic materials; and biohydrogen production from lignocellulosic biomass by extremely halotolerant bacterial communities from a salt pan and salt-damaged soil.

This book's first sister book, *Natural Resources and Control Processes* (Volume 17), covers the topics on the management of agricultural livestock wastes for water resources protection; application of natural processes for environmental protection; proper deep-well waste disposal, treating and managing industrial dye wastes; health effects and control of toxic lead in the environment; municipal and industrial wastewater treatment using plastic trickling filters for BOD and nutrient removal; chloride removal for recycling fly ash from municipal solid waste incinerator; recent evaluation of early radioactive disposal and management practice; recent trends in the evaluation of cementitious material in radioactive waste disposal; extensive monitoring system of sediment transport for reservoir sediment management; and land and energy resources engineering glossary.

This book's second sister book, *Environmental and Natural Resources Engineering* (Volume 19), covers the topics on understanding, conservation, and protection of precious natural resources – bees; waste reclamation for reuse, biological processes

for water resources protection and water reuse, and removal of endocrine disruptors for environmental protection; cooling and reuse of thermal discharges; basic hydrology, water resources, and DAF boat plant for lake restoration; cadmium detoxification by sintering with ceramic matrices; treatment of vegetable oil–refining wastes; environmental engineering education; environmental control of pests and vectors; new book reviews; and glossary of environmental and natural resources engineering.

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Newtonville, NY, USA — Lawrence K. Wang
Newtonville, NY, USA — Mu-Hao Sung Wang
Cleveland, OH, USA — Yung-Tse Hung
Newtonville, NY, USA — Nazih K. Shammas

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Chapter 9
Agricultural Waste-Derived Adsorbents for Decontamination of Heavy Metals

Soh-Fong Lim, Siti Kartina Abdul Karim, S. N. David Chua, and Bee-Huah Lim

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Abstract The growing concerns on the environment in recent years have influenced the usage of renewable sources as alternative materials to create a platform for the development of new technology with possible economic potential. Adsorbents derived from agricultural wastes have hidden economic values which could be benefited by transforming the agricultural wastes into valuable and useful products. Numerous agricultural wastes such as skins/peels, cores, pits, leaves, brunches, and pericarp are being produced in plantation and processing industries. The agricultural

S.-F. Lim (✉) · S. N. D. Chua
Faculty of Engineering, Universiti Malaysia Sarawak, Kota Samarahan, Sarawak, Malaysia
e-mail: sflim@unimas.my; csndavid@unimas.my

S. K. A. Karim
Faculty of Applied Sciences, Universiti Teknologi MARA, Kota Samarahan, Sarawak, Malaysia
e-mail: sitik094@uitm.edu.my

B.-H. Lim
Fuel Cell Institute, Universiti Kebangsuan, Malaysia, Bangl, Selangor Darul Ehsan, Malaysia
e-mail: beehuah@ukm.edu.my

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wastes have exhibited the potential usage as an adsorbent to remove contaminants from water environment which conserve the natural environment and resources mainly in the ecology system sustainably, for the reason that this utilization converts the agricultural wastes into value-added product and at the same time decontaminate polluted water source. This application on the utilization of agricultural wastes is not only good for a sustainable environment but is also suitable for rural economic development, meaning possible increases in profit for farmers and the agricultural industry. This chapter provides insight on some findings on heavy metal removal by adsorbents produced from agricultural wastes. The chapter also discusses the situation of the heavy metals in the environment, parameters affecting the adsorption process of the heavy metals, kinetic models, and adsorption isotherms that are associated with the agricultural waste-derived adsorbents. The development of the adsorbents from agricultural waste biomass and the prospect of developing hybrid adsorbent and magnetic adsorbent have attracted many researchers worldwide in performing research work on the application to water and wastewater treatment.

Keywords Agriculture · Agricultural wastes · Adsorbents · Heavy metals · Kinetics · Adsorption isotherm · Equilibrium time · Adsorbent dosage · Solution pH · Kinetic model

Nomenclature

α	Initial adsorption rate in mg/g·min unit
β	Desorption constant in g/mg unit
ε	Polanyi potential
Al	Aluminium
As	Arsenic
As(III)	Arsenite
As(V)	Arsenate
B(II)	Boron(II) cation
Cd	Cadmium
Cd(II), Cd^{2+}	Cadmium(II) cation
$Cd(OH)^{+}$	Cadmium hydroxide ion in its +1 oxidation state
C_0	Initial concentration of the solution in mg/L unit
C_c	Equilibrium concentration in mg/L unit
C_i	Initial concentration in mg/L unit
Co	Cobalt
Co(II)	Cobalt (II) ion
Co-Fe-MBC	Cobalt-iron-magnetic biochar
$Co(NO_3)_2$	Cobaltous nitrate
Cu	Copper
Cu(II)	Copper (II) cation
Cr	Chromium
Cr(III)	Chromium (III)