Unit Treatment Processes in Water and Wastewater Engineering

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Author's Note

Water and wastewater treatment technology is continually evolving in pursuit of better and more economic systems for the production of wholesome drinking water and more effective and efficient systems for the control of water pollution. Advances have been achieved through the combined inputs of many sources including the ever expanding body of fundamental scientific knowledge, advances in process engineering achieved through applied research and innovative design, developments in the fields of instrumentation, process control and electronic data management and, not least, the impact of ever increasing environmental regulations.

This publication presents a comprehensive coverage of the theory, analysis, technology and design of the process engineering used in the production of drinking and other high quality waters, the treatment and disposal of wastewaters and the sludge residues arising therefrom. It was first published in hardcopy format in 1997 by John Wiley & Sons under the title 'Unit Treatment Processes in Water and Wastewater Engineering' as part of the Wiley Series in Water Resources Engineering.

This revised soft copy edition is a free publication of Aquavarra Research Limited (available at www.aquavarra.ie/publications). It is the author's hope that it will be of benefit to students of civil, chemical and environmental engineering as well as design engineers and water industry technical personnel.

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Preface

Water is one of the prime natural resources, an essential commodity for the living systems that constitute the biosphere, unique in its properties – the only substance to exist in all three phases, solid, liquid and gaseous, within the temperature range of the natural environment, vulnerable to contamination and pollution by human activities, continually renewed by the natural hydrological cycle of evaporation, vapour transportation and precipitation. Water supply and sanitation systems are primary infrastructural needs of communities world-wide, playing a key role in the promotion of public health and the elimination of disease. Water is of course put to many other uses in addition to its drinking water and sanitation uses. High purity waters are used, for example, in the pharmaceutical and semiconductor industries. Water is widely stored and distributed for the irrigation of crops in regions of low rainfall and is used in the electrical power industry for hydropower generation, energy storage and cooling. Thus the engineering associated with water resources management and use is multi-faceted.

This treatise deals with the technologies used to control and modulate water quality to meet the regulatory standards that govern its use for drinking and sanitation purposes and its related use in industrial manufactures. It deals with the range of treatment processes used in the production of drinking and other high quality waters, in the treatment of municipal and industrial wastewaters and in the treatment and disposal of sludge residues. In general, the presentation of the subject matter proceeds sequentially from basic principles through analytical/experimental methods to the development of process design methodologies. Processes are treated as unit operations, emphasising those process fundamentals which can be applied to all process applications.

Chapter 1 presents basic information on water as a substance, with particular reference to the physical and chemical properties of relevance to process technology and design.

Chapters 2 and 3 cover the behaviour of particulate matter in water, including particle settling behaviour, the characteristics of colloidal systems and suspensions and methods for their destabilisation.

Chapters 4, 5 and 6 relate to particle removal processes, including sedimentation, flotation and filtration.

Chapter 7 reviews dissolved species in water. Chapters 8, 9 and 10 relate to dissolved species removal by adsorption, chemical precipitation and ion exchange.

Chapter 11 presents the fundamentals of biological processes and serves as a foundation for the following Chapters 12 and 13 which deal with aerobic suspended floc and biofilm processes technology and design, and for Chapter 15 which deals with the corresponding anaerobic process technologies.

Chapter 14 covers the topic of gas-liquid transfer, the more important process applications of which are to be found in the aeration systems of activated sludge processes and in the air saturation systems associated with dissolved air flotation processes.

The characteristics, treatment and disposal of the sludge residues derived from the various processes used in water and wastewater treatment are the subject matter of Chapter 16.

Chapter 17 covers the topic of water disinfection, which is of critical importance in preventing the spread of waterborne disease.

It is my hope that this treatise will be of benefit to students of civil, chemical and environmental engineering and that it will also serve as a reference work for water system design engineers and water industry technical personnel.

I have endeavoured to acknowledge throughout the text the numerous sources on which I have drawn in the compilation of this treatise. In this context, I would like to make a special reference to the seminal 2-volume publication on the same subject, authored by Fair, Geyer and Okun, published by John Wiley Inc. in 1968, which has had a formative influence on my approach to the subject.

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