Contents

Introduction to the *Water and Wastewater Process Technologies* Series

Unit operations are linked together in a flowsheet to provide water and wastewater treatment.

This series of texts, termed *modules*, is designed to provide an education in water and wastewater treatment from a process engineering perspective. At the end, you should have a thorough understanding of the design, operation and management of water and wastewater treatment processes. This might be the treatment of an industrial effluent to a standard acceptable for disposal to sewer, or treatment of municipal sewage to meet an environmental discharge consent, or the production of water suitable for drinking abstracted from a river. In almost all cases, a single "process", usually termed a *unit operation*, will not be able to achieve the required level of treatment. Treatment is achieved through linking the right unit operations in a *flowsheet*.

With the emphasis on the public utility infrastructure and environmental impacts, rather than the processes, technologies required for provision of potable quality water and those required for treatment of wastewaters have been taught separately. Teaching tends to follow an "application down" approach. Elements of training at almost all levels of the water sector are usually presented in this way. For example, a programme on wastewater treatment might be structured with courses entitled *Introduction to municipal wastewater treatment; Advanced municipal wastewater treatment; Low cost sewage treatment; Industrial effluent treatment;* and so on. For drinking water, it is likely to be an *Introduction to potable water treatment*, followed by *Advanced potable water treatment*, etc. This means that unit operations relying upon different scientific principles are taught together, arguably making it difficult to instil a true understanding of the principles governing the design, operation and management of the unit operations.

The "application down" approach looks even more flawed when we consider today's needs for different qualities of water other than potable supply or municipal sewage treatment, in addition to ever more stringent quality standards. Examples might include provision of ultra-pure water for microchip production, water suitable for crop irrigation, in-building water recycling for non-potable uses, potable supply in rural areas, water for manufacturing and treatment of industrial effluents, particularly when high in inorganic content. Very different processes may be needed to provide solutions in these situations.

When designing, operating or managing a process to provide a certain quality water, it is better to first consider the individual unit operations that when linked together form the required process flowsheet for the application. This is a chemical engineering approach, as it is about the conception, development and exploitation of processes and their products. The process could be water or effluent treatment; the product a less polluted aqueous stream.

Understand water and wastewater treatment through a chemical engineering approach.

Chemical engineers use physical, chemical and biological sciences and mathematics to provide a systems approach to the understanding of changes which take place in processes, from the molecular to global scale, and to establish methods which can be employed to achieve required changes in composition, energy content, structure or physical state. In other words, chemical engineering uses a "science up" approach to solving process problems.

This series of modules teaches the removal of pollutants from water based on just such a "science up", chemical engineering approach. To understand a unit operation, the fundamental biology, chemistry or physics underlying that unit operation needs to be properly understood. Nearly all unit operations are applicable to different levels of water and wastewater treatment, e.g. ultrafiltration

membrane processes can be used in flowsheets for treating municipal and industrial effluents, as well as potable supply and pure water. The fundamental concepts of transmembrane pressure, flux rates, fouling etc, remain the same, whatever the application. Therefore the texts in this series are organised on just such a "science up" basis.

The first module, *Process Science and Engineering*, covers the chemistry, biology and chemical engineering required for a proper understanding of the unit operations covered in the main technical modules. The second module, *Principles of Water and Wastewater Treatment Processes*, introduces these unit operations, describing their overall form, performance and application. These two modules provide an introduction to the remaining five modules that describe the unit operations based upon their scientific principles: *Biological Processes, Chemical Processes, Physical Processes, Membrane Technology,* and *Sludge Treatment, Management and Utilisation*.

SERIES MODULES

- Process Science and Engineering
- Principles of Water and Wastewater Treatment Processes
- Biological Processes
- Chemical Processes
- Physical Processes
- Membrane Technology, and
- Sludge Treatment, Management and Utilisation

School of Water Sciences at Cranfield University

The series of texts on *Water and Wastewater Process Technologies* has been developed from the modular Masters programmes delivered by the School of Water Sciences at Cranfield University.

The School of Water Sciences specialises in treatment, use and management of water.

The School of Water Sciences undertakes research and education in technology and associated scientific, engineering and policy issues for the treatment, use and management of water. It is based on the Cranfield campus of Cranfield University, an institution unique in UK Higher Education. The University was founded as the Royal College of Aeronautics in 1946 and now occupies three campuses in the south of England. The Cranfield campus is approximately 80 km north of London and is the largest postgraduate-only campus in the UK. In addition to a fully operational airfield, it has its own sewage treatment works. Here the School of Water Sciences has a pilot-plant facility. In addition there are state-of-the-art laboratories for undertaking research and teaching in water and wastewater processing on the campus. These include modern analytical instrumentation facilities, chemistry and microbiology laboratories and experimental rig areas

Water Sciences at Cranfield offers a comprehensive programme of Masters and Doctoral research degrees.

Research programmes offered include the 3 year full-time Doctorate of Philosophy (PhD) and the 4 year Engineering Doctorate (EngD). The latter combines an in-depth technical thesis with a high-level management programme. Research projects always involve support from the water industry, often financial as well as technical. Research themes include municipal water and wastewater treatment, industrial effluent treatment, environmental monitoring and modelling, groundwater protection, pollution control, odour treatment and management, waste management, technology policy, water and society, water reuse and biosolids disposal. All research students are encouraged to publish in scientific journals during their studies and are given the opportunity to present their research at international meetings. Each student is assigned an academic member of staff who supervises the researcher throughout their project.

Masters Programmes in
Water Pollution Control Technology
Water and Wastewater Technology
Water and Wastewater Engineering

The teaching programme of the School centres on the full-time (*Water Pollution Control Technology, Water and Wastewater Engineering*) and part-time (*Water and Wastewater Technology*/*Engineering*) MSc courses. All of these are modular in structure based upon the texts in the series *Water and Wastewater Process Technologies*.

The full-time MSc is available as one year of intensive study. The course consists of ten taught modules, a series of design projects undertaken in teams and a thesis project. A Postgraduate Diploma (PgD) can be taken over 7 months and includes 10 taught modules and the group design projects. A Postgraduate Certificate (PgC) can be taken over 4 months and includes 6 taught modules along with a design project.

The part-time MSc can be taken over 2 to 5 years whilst in employment.

The taught modules include the technical subjects that form the series *Water and Wastewater Process Technologies* as well as modules on technical management subjects such as project management and reliability engineering and risk management.

During design projects, the students work in multi-disciplinary teams to produce detailed process flowsheets for a variety of treatment problems. Concepts learned during the taught modules are put into practice. Designs include advanced potable water treatment, municipal wastewater treatment and industrial effluent processes.

The full-time MSc thesis projects are undertaken in Water Sciences' modern facilities on the campus, or more often off-site in co-operation with international and UK water companies. Thesis projects have been sponsored by many of the world's largest water companies, including all ten privatised water and sewerage utilities in England and Wales. There is also the opportunity to undertake the thesis project at other universities across the globe. Part-time students usually undertake thesis projects with their employer.

Students from the UK, Europe and the rest of the world attend the full-time MSc courses. Countries represented include Argentina, Brazil, Columbia, France, Mexico, Norway, Italy, Portugal, Spain, Syria, Taiwan and Thailand. The undergraduate qualifications of students have included degrees and diplomas in many science and engineering subjects. These have been chemical, civil and mechanical engineering, biological sciences, chemistry, environmental sciences and many other subjects.

The School of Water Sciences organises conferences in key areas of technology appropriate to the water sector. Generally, each conference includes presentations by leading international figures working in these specialist fields. These presenters are drawn from industry as well as academia. Delegates receive sets of papers that are also published following the close of the conference. These events are often held in conjunction with other bodies such as the IWA, and may include a small exhibition organised parallel to the conference so that delegates can meet with personnel from companies marketing associated products and services.

For further details on Masters level courses, research and conferences run by the School of Water Sciences please see http://www.cranfield.ac.uk/sims/water/
or
Email: watersciences@cranfield.ac.uk

or write to:
The School of Water Sciences, Cranfield University, Cranfield, Bedfordshire, MK43 0AL, UK

Tel: +44 (0)1234 750111
Fax: +44 (0)1234 751671

Editors

Series Editor

Professor Tom Stephenson is Professor of Water Sciences at Cranfield University. He graduated with a BSc in Biochemistry from the University of York, UK, and has a PhD in Civil Engineering from Imperial College, University of London. After a period as a post-doctoral researcher at Imperial, he was appointed Senior Lecturer in Chemical Engineering at Teesside Polytechnic, UK. He joined the School of Water Sciences at Cranfield University in 1990 and became Professor of Water Sciences in 1994. Professor Stephenson is a Chartered Engineer and a Fellow of the Institution of Chemical Engineers and the Chartered Institution of Water and Environmental Management.

Professor Stephenson has developed both full-time and part-time Masters programmes in water and wastewater process technologies at Cranfield. His research interests are centred on wastewater treatment, including biological, chemical and physical processes. Professor Stephenson has consulted for many national and international companies, contributed to government and OECD Reports and has led UK government overseas science and technology missions. He is also a Director of British Water, the leading UK Trade Association for the water industry in the home and international markets. Professor Stephenson participates as regularly as possible in activities endorsed by the Campaign for Real Ale (CAMRA).

Volume Editor

Dr. Simon Judd is Reader in Water Sciences. He has a BSc in Chemistry from the University Bath, UK, and an MSc in Electrochemical Science from Southampton University, UK. Dr Judd took a PhD on electrophoretic depth filtration while in the School of Water Sciences at Cranfield. Dr. Judd subsequently worked in the Chemical Process Development Department at AEA Winfrith, UK, where he continued work on filtration as well as other environmental-related processing. Rejoining Cranfield in 1992, Dr. Judd was promoted to Reader in Water Sciences in 1999. Dr Judd is a chartered chemist and a member of the Royal Society of Chemistry. His main areas of research interest are membrane and chemical processes for water and wastewater treatment, swimming pool water treatment and industrial water recycling technologies.

The Series Editor and Volume Editor acknowledge the technical writing contribution of Mr Richard Hill, Visiting Fellow in Water Sciences.