Biological Wastewater Treatment

GLOBAL SANITATIO GRADUAT SCHOOL

Online Course Series

Theory and principles • Examples and exercises • Experimentation • Case studies

Background

The Biological Wastewater Treatment (BWWT) Online Course Series contains **state-of-the-art** courses based on the IWA Publishing **bestseller** and Best Scientific Book 2022 **winner** "Biological Wastewater Treatment: Principles, Modelling, and Design" 2nd edition, on the complementary textbook "Biological Wastewater Treatment: Examples and Exercises", and on "Experimental Methods in Wastewater Treatment" textbook. Besides these books, the course materials include video lectures and presentations by the **world's leading experts and scientists** who made a significant contribution to wastewater treatment in the last decades. The Series is developed under the framework of the Global Sanitation Graduate School (GSGS) – the world's largest network for postgraduate education on citywide inclusive sanitation (CWIS) managed by IHE Delft Institute for Water Education.

Open access BWWT course package

We are delighted to complement the GSGS portfolio of educational offerings with the Biological Wastewater Treatment Online Course Series - a package of **open access** distance learning courses. The Series consists of **18 courses.** All the courses in the series are **free** and suited for individual use in **self-study** mode, while IHE Delft Institute for Water Education also provides a guided version which includes online guidance, exams and certificates. Each course in the series is **stand-alone** and available as a package consisting of video lectures, recorded experimental procedures, case studies, presentations, assessments and additional study materials. Courses can be studied in any order that suits the user's needs and can all be **downloaded** from the dedicated website (www.studybwwt.online) including the guidelines on how to use the materials. If you need additional support, do not hesitate to contact us.

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BWWT Online Course Series courses

- **Wastewater Treatment Development** 
- **Microbiology and Metabolism** 
- **Wastewater Characteristics** 
- **Organic Matter Removal** 
- **Nitrogen Removal** 
- **Enhanced Biological Phosphorus Removal** 
- **Sulphur-based Wastewater Treatment** 
- **Wastewater Disinfection** 
- **Aeration and Mixing** 
- **Bulking Sludge** 
- **Aerobic Granular Sludge** 
- **Final Settling** 
- **Membrane Bioreactors** 
- **Modelling Activated Sludge Processes** 
- **Process Control** 
- **Anaerobic Wastewater Treatment** 
- **Biofilm Modelling and Reactors** 

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Theory and principles
Examples and exercises
Experimentation
Case studies

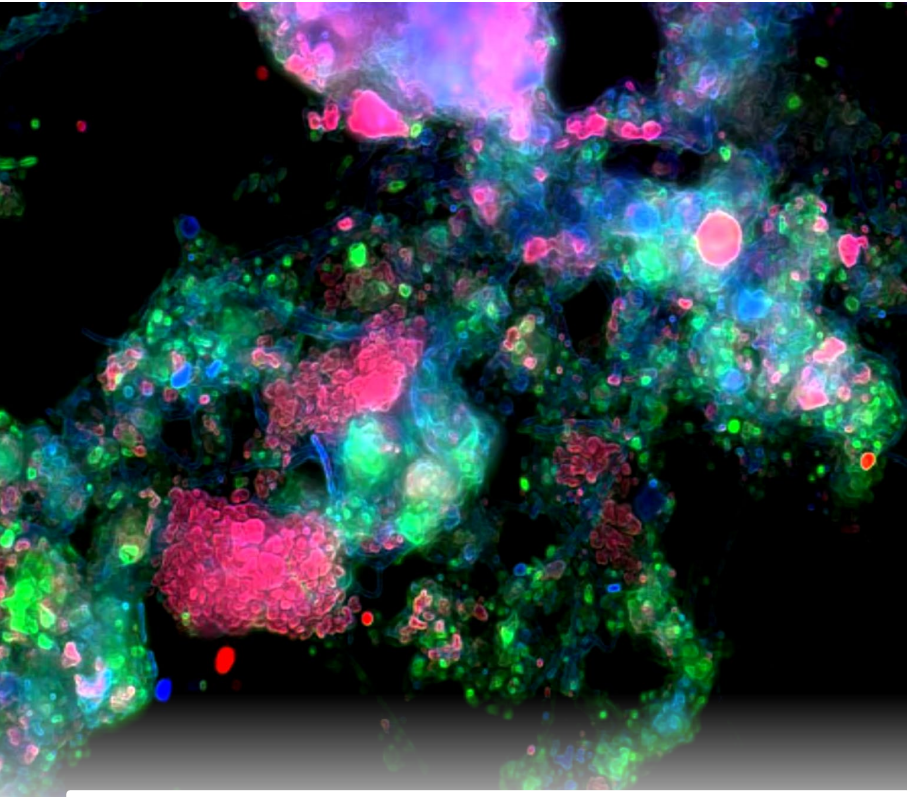
Target groups

The courses are designed for students, scientists, laboratory staff, plant operators, technologists, designers, engineers, and others who wish to engage with the scientific and bioprocess engineering principles of wastewater treatment science and technology with deeper insight, advanced knowledge, and greater confidence built on stronger competence.

Enrol on our courses today and enhance your knowledge and skills on biological wastewater treatment!

Wastewater Treatment Development

Sanitizing human excreta was already addressed by the ancient civilizations while wastewater treatment development was the most visible in the 20th century. By the end of the course, you will be familiar with global drivers for sanitation and you will learn about history of wastewater treatment starting from the ancient civilisations and developments during the 18th and 19th century. Particular focus is on rapid progress during the 20th century that include the discovery of the activated sludge process and the development of the myriad of its variations, and the introduction of variety of biofilm-based technologies, addressing carbon, nitrogen, phosphorus and sulphur transformations in wastewater treatment, sewage sludge treatment and options for resource recovery.



Microbiology and Metabolism

Microorganisms are central to biological wastewater treatment. This contemporary course covers basic topics of wastewater microbiology by questioning: “what are microorganisms and how do they grow?”. It progresses from descriptions of microbial cells and physiology, metabolic diversity and trophic groups, and niche establishment along environmental gradients, to formulations of stoichiometry, thermodynamics, and kinetics of microbial growth useful for modelling. It further addresses microbial ecology and ecophysiology methods to track microorganisms and functionalities in sludge. The course scope and coverage are expanded with examples and exercises that will enrich your experience in this exciting field. Several videos deal with experimental aspects of modern microbiology and molecular methods applied in wastewater treatment, and with simple mathematical models of microbial interactions in communities. By the end of the course, you will be able to approach microbial processes involved in nutrient removal with confidence.

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Wastewater Characteristics

Wastewater characterization is essential for any wastewater study or a project, be at laboratory-, bench-, pilot- or full-scale. This interesting course explains characteristics of flows in both sewered and non-sewered sanitation. After completion of this course you will understand wastewater types and their characteristics, physical and chemical occurrence of its components, microorganisms present in the sewage, and characteristics of carbon, nitrogen, and phosphorus, including their fractionation. You will learn about population equivalent, importance of ratios between various components in wastewater, domestic and non-domestic sewage components, various domestic sewage sub-streams, and internal loads at wastewater treatment plant. You will become familiar with non-sewered (onsite) sanitation flows and basic definitions of terms. Finally, the course will enable you to understand the fundamental principles of wastewater and sludge sampling and of the design of a sampling program within the wider urban context.

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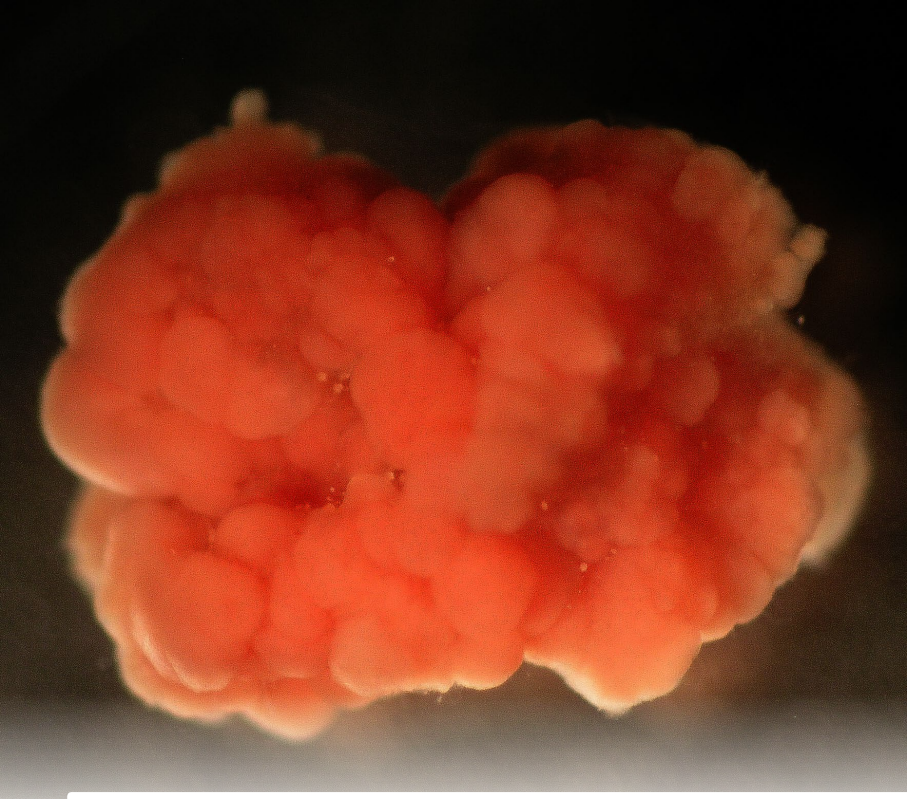
Organic Matter Removal

Removal of organic matter is the most common requirement in wastewater treatment. This course contains fundamentals of organic matter fractionation and fate of its components in the biological reactor, it explains activated sludge system constraints, deals with steady-state and dynamic-simulation models, provides a detailed design example with focus on calculations, mass balances, reactor sizing, and essential considerations as concentrations in the reactor, carbonaceous oxygen demand, excess sludge production, food-to-microorganism ratio and load factor, capacity of the system, system design and control, role of hydraulic retention time, and the selection of sludge age. By the end of the course you will be able to engage with the scientific and bioprocess engineering principles and experimentation of organic matter removal with deeper insight, advanced knowledge and greater confidence.



Nitrogen Removal

Nitrogen removal is the process most extensively studied in the history of wastewater treatment. This course covers fundamental, design and experimental aspects of nitrification and denitrification processes, including biological and process kinetics, factors influencing processes, nitrification and denitrification rates and potential and other relevant aspects. A complete design example is included with detailed development and demonstration of design procedure, sizing of the system, calculation of oxygen demand and other process requirements. You will also become familiar with nitrogen cycle, impact of side-stream processes, and novel nitrogen removal processes such as nitrite-based nitrogen removal, anaerobic ammonia oxidation, and bio-augmentation, including SHARON®, ANAMMOX®, CANON® and BABE® processes, and you will benefit from several interesting case studies of application of novel nitrogen removal technologies in practice.

Enhanced Biological Phosphorus Removal

This state-of-the-art course presents various aspects of enhanced biological phosphorus removal (EBPR) such as fundamental principles, microbiology and mechanisms involved, factors affecting EBPR performances, process configurations, and models for EBPR. In addition, you will get familiar with EBPR design procedures and you will understand the influence of operational factors on full-scale EBPR plants and integration of EBPR and biological nitrogen removal. You will be able to expand and test your knowledge by using carefully prepared examples and exercises. The course also includes case studies and videos demonstrating experimental procedures involving mixed cultures of activated sludge and enriched cultures with Phosphate Accumulating Organisms (PAOs). By the end of the course you will be equipped with the latest knowledge and essential skills to help you carry on practical and academic tasks with increased confidence.

Sulphur-based Wastewater Treatment

This novel course on sulphur-based conversions in wastewater treatment deals with fundamentals of sulphate-reducing bioprocesses, microbiology, factors affecting conversions, etc. Particular focus is on sulphur-driven autotrophic denitrification and on SANI® process development, modelling and application. Sulphur conversion-based resource recovery makes part of this course too. You will get familiar with design procedures, practical examples of real-life applications, and experimental methods on sulphur-based conversions in activated sludge systems. Completion of this course will enable you to apply advanced knowledge of sulphur-based wastewater treatment in both practical and research settings and to learn about future perspectives in this exciting field.

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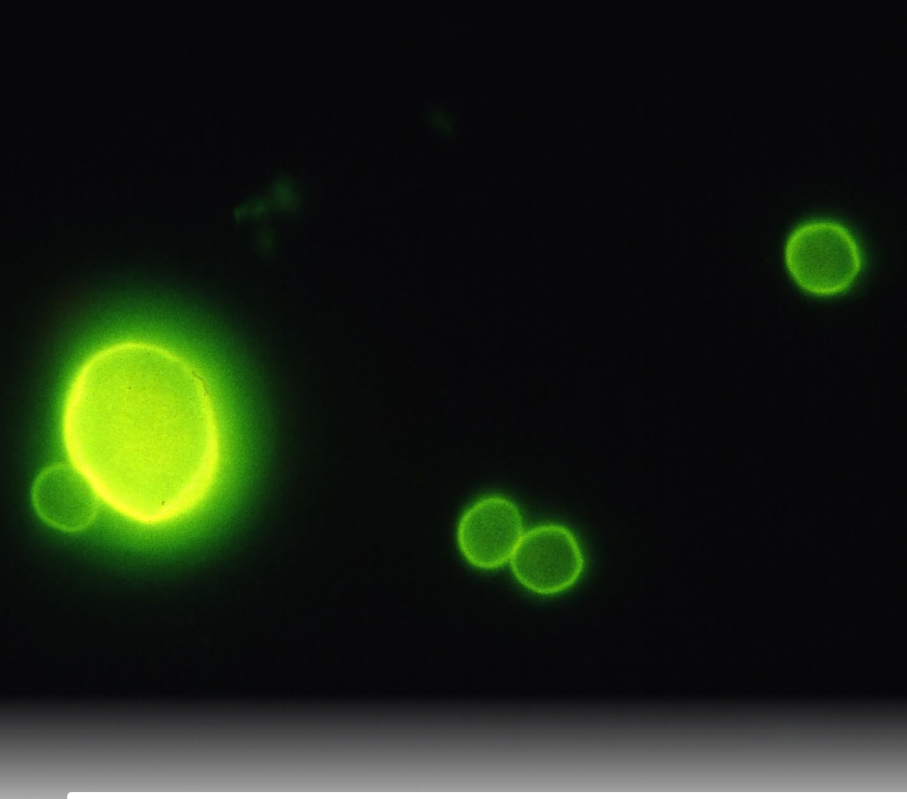

Wastewater Disinfection

This course deals with a trending field of wastewater disinfection that starts with explanation of indicator organisms concept and continues about disinfection with halogens (chlorine), peracids (peracetic acid), and ultraviolet radiation. You will also understand underlying aspects of disinfection kinetics and of comparison of disinfection kinetics among common disinfectants. Furthermore you will get familiar with deterministic and probabilistic process models, disinfection applications in wastewater treatment, and future directions in the field. A comprehensive package of examples and exercise will help you to expand and test your knowledge on the subject. The course also includes practical examples of application of disinfection in wastewater treatment. By the end of the course you will be able to deal with the subject with increased confidence.

Aeration and Mixing

This motivating course covers various aspects of aeration and mixing in activated sludge wastewater treatment. Aeration fundamentals and technology aspects include oxygen transfer in clean and process water, and mysterious alpha factor, fine and coarse bubbles and droplets, bubble and mechanical aeration, centrifugal and high purity oxygen air blowers. You will also learn about factors (sludge retention time, role of selectors, airflow rate, diffuser density, fouling scaling and cleaning, reactor depth, mixed-liquor concentration, temperature and pressure, impact of hydrodynamic, daily dynamic and alpha factor) affecting oxygen transfer. Design algorithms, aeration and energy and sustainable aeration practices are also part of this practical curriculum. Many examples and exercises complement the course as well as case studies and most common experimental methods. By the end of the course you will gain new insights about aeration and mixing.

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Bulking Sludge

Bulking sludge is a phenomenon in wastewater treatment that continuously attract attention of wastewater treatment practitioners and scientists. In this interesting course you will learn about relationship between morphology and ecopsychology following the microbiological and morphological-ecological approaches. You will familiarize with the filamentous bacteria identification and characterization, general theories to explain bulking sludge (diffusion-based selection, kinetic selection, and storage selection). Remedial actions such as aerobic, non-aerated, anoxic and anaerobic selectors are also part of the course. Finally you will understand the basic principles of mathematical modelling of filamentous bulking and you will have opportunity to embark on examples and exercises complemented with selected case studies. By the end of the course you will have in-depth understanding of the bulking sludge phenomenon in activated sludge systems.

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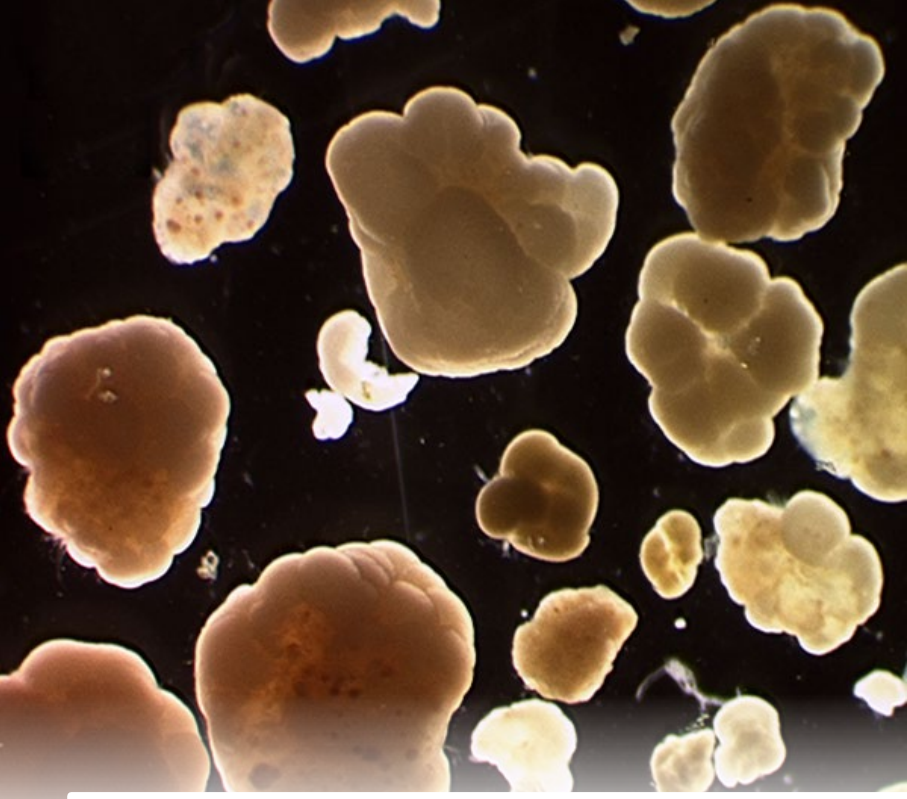

Aerobic Granular Sludge

Aerobic granular sludge is an emerging technology with higher sludge concentration and higher efficiency compared with conventional activated sludge systems. This state-of-the-art course covers important considerations for selecting aerobic granular sludge, kinetics of aerobic granular sludge, process control, design considerations, and resource recovery aspects. Case studies, including the Nereda® technology are also part of the course materials, as well as examples and exercises to expand and check your knowledge on the subject. After completion of this course you will understand the basic principles of aerobic granulation and technology, and its applicability to modern wastewater treatment practice.

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Final Settling

Final settling is the most common way of solid-liquid separation in conventional activated sludge systems. The first part of this course deals with functions of secondary settling tanks (clarification, thickening and storage), different settling tank configurations in practice including most common operational problems, and measurements of sludge settleability. You will also get familiar with the flux theory for estimation of settling tank capacity and other methods for design and operation of secondary settling tanks such as empirical design, WRC design, ATV design and STOWA design. At the end of the course you will be able to compare settlers designed using different methods. Modelling approaches to secondary settlers are also included as well as examples and exercise to test and broaden your knowledge. Case studies and standard experimental methods for the evaluation of sludge settling properties are also part of this informative curriculum.

Membrane Bioreactors

Filtration of activated sludge by membranes is an emerging technology in wastewater treatment substituting traditional settling tanks for solid-liquid separation. This innovative course covers fundamental principles of membrane separation and provide an overview of membrane reactors. You will also learn about performance and effluent quality of membrane bioreactors (MBR), membrane fouling and control, and cleaning procedures of fouled membranes and other fouling control methods. Part of the curriculum deals with MBR plant design, operation and maintenance, and practical applications, including case studies. The course also explains the future trends in MBR technology and includes myriad of examples and exercise. By the end of this course you will have advanced knowledge about MBR systems that will enable you to approach this technology with increased confidence based on stronger competence.

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Modelling Activated Sludge Processes

This course is designed for those who wish to learn about modelling of activated sludge processes and includes modelling basics, aim and scope, model building and general set-up, stoichiometry, kinetics, transport and matrix notation. You will also get deep insight into stepwise development of the biokinetic model ASM1 as well as the fundamentals of other activated sludge models (ASM). The ASM toolbox is also introduced as well as modelling challenges and future trends. The examples and exercises section of the course expands on conceptual modelling of non-sewered sanitation technologies as well on integrated citywide inclusive sanitation modelling. The course covers variety of case studies and examples of integrated modelling of sewer systems, wastewater treatment plants and receiving waters using different models and modeling simulators. By the end of the course you will be ready to embark on modelling studies.

Process Control

This interesting course deals with process control and automation in wastewater treatment. It explains the driving forces and motivation for control, disturbances in wastewater treatment systems, the role of control and automation, instrumentation and monitoring equipment and many other operational aspects. You will learn about the importance of dynamics, manipulated variables and actuators (e.g. hydraulic variables, chemical and carbon addition, and air or oxygen supply), and basic control concepts. Examples of feedback in wastewater treatment systems are also included, as well as integration and plant-wide control and implication of process control on costs. The course is rich in practical examples and is invaluable for those who want to deepen their insight in this important area of wastewater treatment.

Anaerobic Wastewater Treatment

The course entails definition and environmental benefits of anaerobic wastewater treatment processes, microbiology of anaerobic conversions (e.g. hydrolysis, acidogenesis, acetogenesis, methanogenesis), prediction of methane production, impacts of alternative electron acceptors, working with COD balances, immobilization and sludge granulation etc. You will also get insight in various anaerobic reactor systems, and in particular upflow anaerobic sludge blanket (UASB) reactors, and anaerobic process kinetics. Anaerobic treatment of domestic and municipal sewage and of black water in new sanitation systems is also part of the course. Finally you will test and expand your knowledge by studying examples and exercises and you will enjoy variety of international case studies especially prepared for this course.

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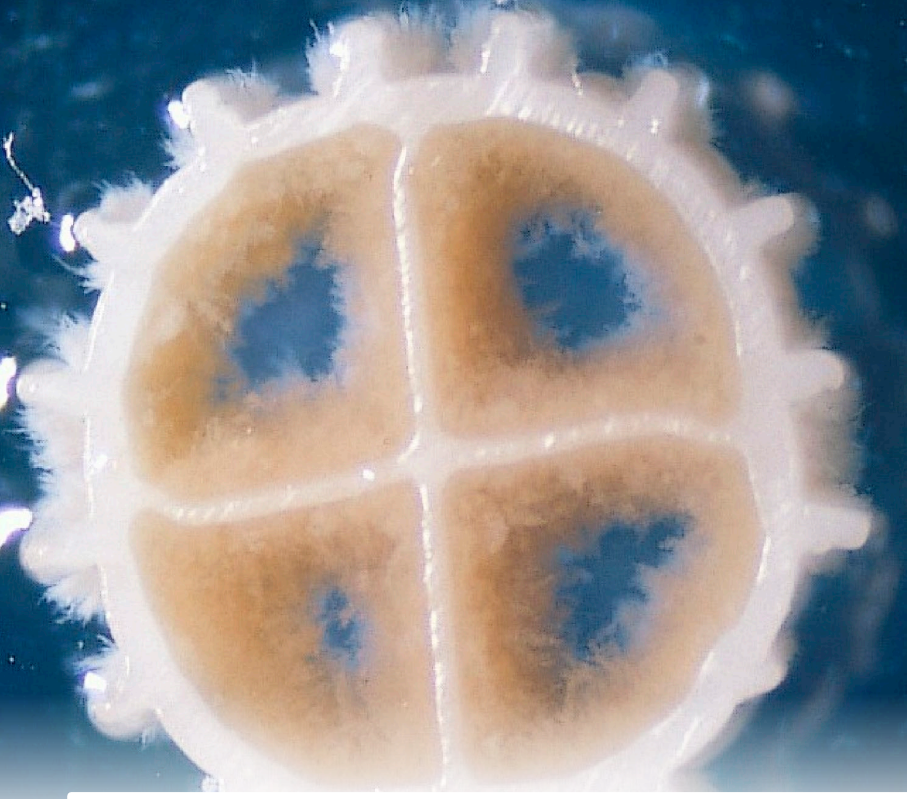

Biofilm Modelling and Reactors

This novel course teaches bout biofilm modelling and reactors in wastewater treatment. It starts with the definition of biofilms, motivation for modelling and modelling approaches for a biofilm, and deals with in-depth insights in modelling components and steps in the process. It provides explanation of biofilm reactor modelling in practice, derived and model parameters, and available modelling tools. The second part of the course deals with various biofilm reactors (trickling filters, rotating biological contactors, submerged fixed-bed biofilm reactors, fluidized and expanded-bed reactors, granular sludge reactors, moving-bed biofilm reactors, hybrid biofilm/activated sludge reactors, and membrane-attached biofilm rectors). You will also learn about design parameters and how to determine maximum design fluxes and loading rates, and several other design considerations. In addition, several examples and exercises are included in the course.

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Chinese National Engineering Research Center for Control and Treatment of Heavy Metal Pollution (Hong Kong Branch)

TU Delft

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Global Sanitation Graduate School

The Global Sanitation Graduate School (GSGS) is a platform to facilitate the development and empower the dissemination of knowledge on sanitation through postgraduate (MSc) programs, online (self-study and instructor-led) courses, face-to-face (on-campus) courses and tailor-made training so that the sanitation challenges can be embraced with deeper insight, advanced knowledge, and greater confidence.

This rapidly-growing global network of currently 55 universities aims to yield 10,000 champions in developing and implementing sanitation in the context of the UN Sustainable Development Goals by the year 2030. The GSGS offers a variety of course materials as open courseware and is continuously updating its courses to remain at the forefront of academic and professional developments in the field. It is rapidly expanding and welcomes new members.

GSGS is supported by the Bill & Melinda Gates Foundation (grant OPP1192599) and is managed by IHE Delft Institute for Water Education.

www.sanitationeducation.org

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