IWA SPECIALIST GROUP

NEWSLETTER

INSTRUMENTATION CONTROL AND AUTOMATION

the international water association

July 2020

Content

WRITE TO US!

Editor: Ángel Robles

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Ángel Robles

Juan Antonio Baeza

Message from Chair

Dear ICA-SG members,

Welcome back to the Newsletter of the IWA Instrumentation, Control and Automation Specialist Group (ICA-SG). It is remarkable the change that has taken place since the last Newsletter six months ago. The COVID-19 crisis has led to a situation where information and communication technologies have taken on an even more predominant role in everyday life.

***Water and wastewater treatment systems** have been highlighted as critical systems for society and it has been necessary to keep them in perfect working order. In a world with limited mobility due to the pandemic, there is a **greater need for updated information** on the systems we need to monitor, supervise and control. **Instrumentation, control and automation (ICA)** are the technologies that have allowed us to keep our systems working optimally. This has been just a foretaste of **future treatment systems**, in which the need for manual work will be reduced thanks to a high level of automation with the use of self-calibrating, self-cleaning instrumentation with reduced maintenance requirements, intelligent pumps with self-diagnostic systems, advanced controllers coordinated by supervisory systems... **Concepts such as Digitalization**, Digital Twin, IoT, Artificial Intelligence, Meta-Data, Decision Support, Predictive and corrective automated process operation **will be key in** the future **Water 4.0**. Whoever is prepared in these technologies will surely be a much-demanded professional. It is always a good time to **invest personally in this training**, as it is and will be a sure value for a long time. The needs of **automation and intelligence of the operation** in the industry will always increase. We are **proud to be part of the water sector**, one of the most necessary for society, and also with a specialization in **ICA** that is more and more **essential for any industry**. To be part of the Water-ICA sector, besides being a totally necessary profession with a great future, is a very attractive position for any person with a **vocation of service to society**.*

*Regarding the contents of this **newsletter**, the editor Angel Robles has compiled a good bunch of information about the past and future activities related to ICA: thanks to all the contributors! We look forward to sharing it with the ICA community. We maintain the newsletter as a **good summary of resources for ICA-SG members,** both young and senior professionals, on how to get involved in working groups, task groups, IWA clusters or being informed of activities as webinars or conferences. For example, we include information on*

how to access the On Demand Webinar: Perspectives on Smart Stormwater Networks held during this last period.

*You can also find a new **featured article** "Understanding biological models in microalgae-based Wastewater Treatment processes using Interactive Tools", showing how **interactive tools** and virtual laboratories have emerged in last years to simulate complex models and control systems quickly and easily, allowing real-time interaction between parameter setting and results visualization. In addition, we also present **five summaries of PhD thesis**, information on the IWA **Digital Water Summit**, **webinars**, currently ongoing task groups, a summary of **projects** related to ICA, and **links** to find research groups or companies sharing these interests, upcoming conferences, and **news** from IWA headquarters and IWA publishing.*

*We will be pleased to receive any **ICA related contribution**. If you have information worth sharing, please send it to the editor or any member of the management committee. Finally, don't forget to share any news using **IWA Connect, we are now 1385 members!***

Thanks for sharing our interest in ICA. I hope you enjoy this Newsletter!

We specially thank the following people for their new contributions to this Newsletter: F. Gabriel Acien, Juan Antonio Baeza, Kambiri Cox, José Luis Guzmán, Ulf Jeppsson, Pau Juan García, Guenter Langergrabe, Leiv Rieger, Peter Vanrolleghem, Kris Villez, Eveline Volcke.

WELCOME TO THE ICA SG

The **ICA-SG** provides the monitoring and control tools needed to meet current and future technology innovations for the water and wastewater industries. The methodologies are used to monitor and control unit processes, plant behaviour or large systems involving networks, plants and receiving waters. Research, practical experience, case studies, management problems, operator challenges and integrated solutions of these systems are important parts of the activities of the ICA-SG.

ICA is the technology often considered as an afterthought in traditional urban water management. **ICA has become more relevant and essential** within the water sector due to increasing **digitalization** and interest surrounding **Internet of Things (IoT) and Artificial Intelligence**. Indeed, **digitalization for monitoring, control and decision support throughout the urban water cycle –** including drinking water production and distribution, wastewater collection and treatment, and water reuse – **has become an essential tool** to achieve cost-effective, intelligent and **safe operation.** ICA is also an important tool to **mitigate environmental impacts** despite challenges with aging equipment and increasing populations. **Installation and use of ICA** in existing plants is often **challenging** due to plant design limitations, sensor and data quality problems, and lack of ICA experience within operations staff.

The field of ICA continues to evolve as technologies develop: a **digitalised platform** of the entire urban water sector; development of reliable and cost-effective on-line sensors and advanced controllers; and big data analytics and visualization tools for better cost-benefit analyses. Available data is increasing almost exponentially and can be transformed into valuable information for operator support, improvement of control systems and integrated planning. Plant-wide control will use ICA methodology to coordinate the different systems to attain better energy efficiency, low carbon footprint and enhanced resilience. Resource recovery will require tight control of product qualities, while increased demand of decentralized systems and decision support systems (DSS) will be also important driving forces for ICA development. In summary, **ICA will have a key role in the continuing evolution of water/wastewater systems**.

Learn more about the ICA action fields and priorities of the ICA-SG in the "**About" drop-down** available in the timeline of the Group site.

JOIN THE SPECIALIST GROUP

Membership of the ICA-SG is open to all IWA members. Every IWA member can join an unlimited number of specialist groups through IWA Connect.

To join the ICA group, sign in the IWA Connect and click the menu item "groups". Here you will find an overview of all groups, and you can select "Instrumentation, Control and Automation" to join. You can also search the SG name in the search function in this menu. Once you join, you will see this group under your own profile in IWA Connect.

For any questions, you can go to the "Help" session on IWA connect or use the IWA Connect Guidelines available in the IWA Specialist Groups site.

If you have questions or suggestions on how to use IWA Connect for the ICA group, please feel free to contact Dr. Liu Ye.

MANAGEMENT COMMITTEE

The members of the Management Committee and their roles are summarized in the following table:

Chair	Juan A. Baeza	Spain	JuanAntonio.Baeza@uab.cat
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Website and IWA Connect. YWP	Liu Ye	Australia	l.ye@uq.edu.au
Content manager for Newsletter and website. Liaison officer Industry & Utilities	Oliver Grievson	UK	olivergrievson@hotmail.com
YWP Relations officer	Linda Amand	Sweden	linda.amand@ivl.se
Event coordinator	Yanchen Liu	China	liuyc@mail.tsinghua.edu.cn
Liaison officer IWA Clusters, SG, WG, TG	Joaquim Comas	Spain	joaquim.comas@lequia.udg.cat
Liaison officer Smart water and wastewater systems	Ken Thompson	USA	Ken.Thompson@CH2M.com
Affiliated YWP	Alexandria Gagnon	USA	agagnon@hrsd.com
	Pau Juan García	UK	Pau.JuanGarcia@atkinsglobal.com
	Tri Le	USA	64le@cua.edu
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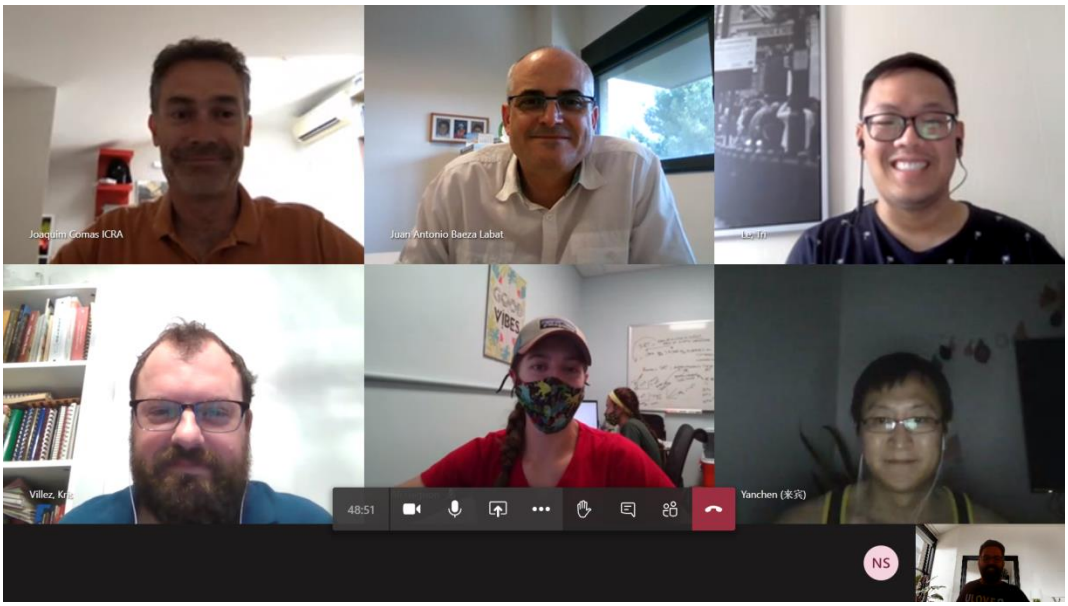


Members of the ICA-SG MC during our last online meeting.

GET INVOLVED IN WORKING GROUPS OR TASK GROUPS

The ICA MC would like to engage our members in ICA-related activities and we think the best way is to foster the creation of Working Groups (WGs) and Task Groups (TGs). If you are interested in working with international experts in the field of ICA, please send an email to Dr. Joaquim Comas**, our WG/TG Coordinator** stating your interest, your availability and a short CV.
If you are already in contact with a group of experts, please submit a proposal to Dr. Joaquim Comas outlining the topic of interest, your group's expertise, planned activities, etc. Joaquín will guide you through the application process, answer your questions and discuss the different group formats with you. Please use the subject line: New ICA Task/Working Group (Your Last Name).

If the proposed topic entails activities also related to the objectives of another SG or requires collaboration of members from another SG, the WG/TG proposal can be supported by both SGs. For further information regarding definition and procedure for starting an ICA hosted IWA Task Group and Working Group, refer to this document (login to IWA Connect first to view).

GET INVOLVED IN WEBINARS

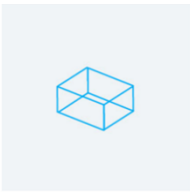
The ICA-MC wants to provide group members with a series of ICA-related webinars to bring continuous development in order to stay abreast with the changing environment circumstances. No matter in which stage of your career you are, these webinars will represent an opportunity of professional updating, learning, training and networking.

Forthcoming webinars will deal with experiences on digitalisation in the water sector, connectivity of instruments, and biological nutrient removal control. If you have any ICA-related webinar proposal, please send an email to Dr. Ángel Robles or visit IWA Learn.

GET INVOLVED IN IWA CLUSTERS

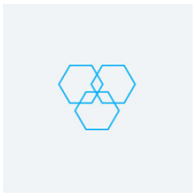
IWA Specialist Groups Clusters are meant to facilitate the cooperation between different specialist groups within IWA or from other associations, in order to tackle some wide-ranging problem or concern, which requires the distinct points of view from several fields of knowledge. Please see the description at http://www.iwa-network.org/clusters.php.

Currently, there are three IWA clusters:



Alternative Water Resources Cluster (AWR)

IWA/ISME BioCluster



Resource Recovery from Water Cluster (RRfW)

Particularly, the ICA-SG has expressed its interest in all clusters, except the BioCluster, and we are currently looking for representatives amongst us for them. **If you are interested in participating, please contact the Management Committee** through Dr. Joaquim Comas.

Readers are invited to contribute to this section of our next Newsletter by sending an article of about two to four pages. This featured article is typically of a practical nature and/or with a close link to industry.

Understanding biological models in microalgae-based Wastewater Treatment processes using Interactive Tools

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The use of microalgae-bacteria consortia for wastewater treatment involves an eco-friendly alternative for sustainable wastewater treatment and an economic way for producing microalgal biomass without nutrient cost [1–3]. Microalgae-bacteria consortia systems are especially complex and vary as a function of the environmental and operational conditions such as the composition of the wastewater [4,5]. To understand these biological interactions, multiple mathematical models have been developed and validated. However, current biological models present a high number of parameters, making it more and more difficult to evaluate and understand in a simple way. As a solution for these problems, interactive tools and virtual laboratories have emerged in last years to simulate complex models and control systems quickly and easily in other disciplines [6]. These tools allow a real-time interplay between the adjustment of parameters and the displaying results. So, these interactive capabilities have been used to develop a new interactive tool to contribute in the understanding of biological models in microalgae-based wastewater treatment processes.

Biological models for the interactive tool

The biological model used in this work considers the existence of three microbial populations: microalgae, heterotrophic bacteria and nitrifiying bacteria. The model involves the oxygen production by microalgae from photosynthetic activity and the oxygen consumption by heterotrophic and nitrifiying respiration. These biological processes are determined by important environmental parameters, such as light intensity, temperature, pH, and dissolved oxygen [5]. Moreover, along with environmental variables, the chemical composition of wastewaters being processed influences on the microbial activities. Therefore, the concentration of nitrogen, phosphorous and biodegradable soluble organic matter have been included in the model too. Finally, three main equations, one for each population, are proposed:

$$PO2_{ALG} = PO2(I) \cdot \overline{PO2(T)} \cdot \overline{PO2(pH)} \cdot \overline{PO2(DO2)} \cdot \overline{PO2(N)} \cdot \overline{PO2(P)} - RO2(I) \quad \text{Equation 1}$$

$$RO2_{Het} = RO2max \cdot \overline{RO2(T)} \cdot \overline{RO2(pH)} \cdot \overline{RO2(DO2)} \cdot \overline{RO2(N)} \cdot \overline{RO2(P)} \cdot \overline{RO2(Ss)} \quad \text{Equation 2}$$

$$RO2_{Nit} = RO2max \cdot \overline{RO2(T)} \cdot \overline{RO2(pH)} \cdot \overline{RO2(DO2)} \cdot \overline{RO2(N)} \cdot \overline{RO2(P)} \quad \text{Equation 3}$$

The equations shown above allow to compose a global equation to calculate the oxygen production by microalgae-bacteria consortia in wastewater treatment (Equation 4):

$$PO2 = PO2_{ALG} - RO2_{Het} - RO2_{Nit} \quad \text{Equation 4}$$

More details about those models can be found in [7].

An interactive tool has been developed using these equations. This tool makes possible simulating four scenarios or biological models:

1. Microalgae wastewater treatment is performed only by microalgal cells and driven by solar radiation intensity only.

2. Three microbial populations coexist in the system (microalgae, heterotrophic bacteria and nitrifying bacteria) and their activity is determined by solar radiation.
3. Wastewater treatment is performed by microalgae cells and their activity is a function of solar radiation and is modulated by the effect of temperature, pH, dissolved oxygen, nitrogen and phosphorous.

The most complex modelling scenario involves both microalgae and bacteria (heterotrophic and nitrifying bacteria) with photosynthesis driven by the intensity of solar radiation and modulated also by temperature, pH, dissolved oxygen, nitrogen, phosphorous and biodegradable soluble organic matter.

Interactive tool description

The interactive tool allows simulating the four possible biologic models for 24 hours quickly and easily. Furthermore, it is possible to simulate all models throughout the four seasons of the year and modify the growth parameters of the microalgae and bacteria populations. Furthermore, the tool allows to visualize the real data for pH, dissolved oxygen, solar radiation, and medium temperature used as input to the biologic models. The tool is available through http://www.eu-sabana.eu/ at the Data and Software website section. Windows and Mac versions are available for free. Figure 1 shows the main screen of the tool.

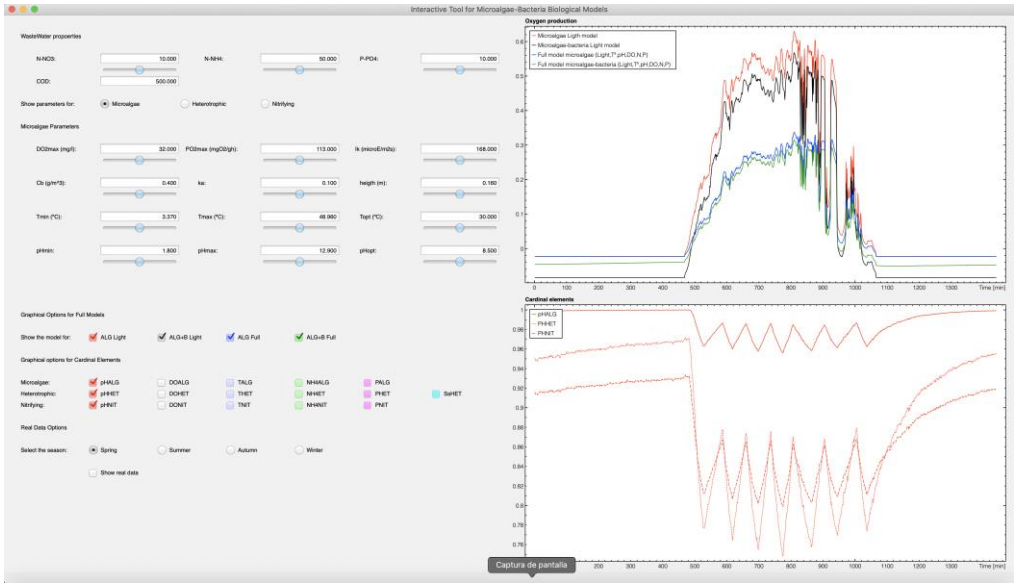
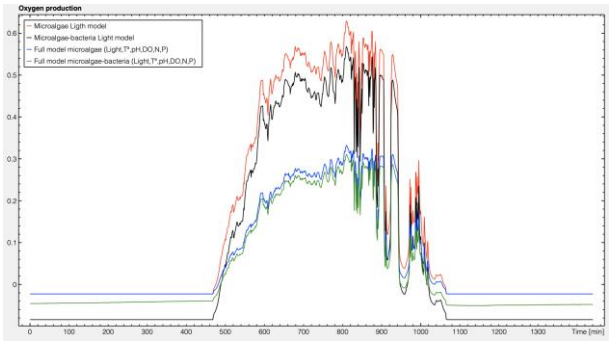


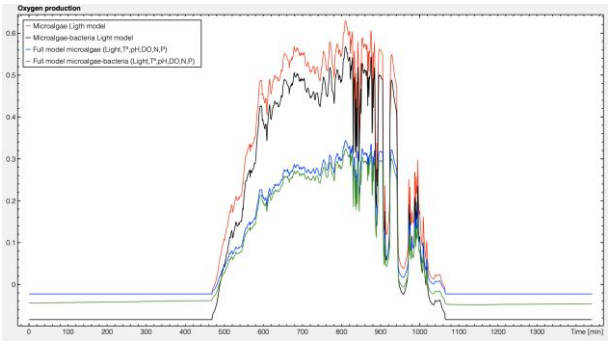
Figure 1. Main screen of the interactive tool.

How it works

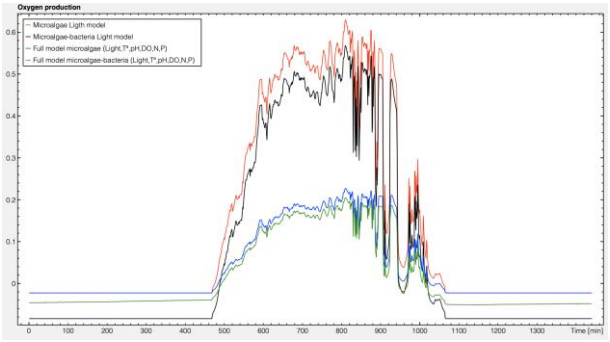
Most the microalgae-based wastewater treatment systems use sewage from wastewater treatment plants in which different types of effluents appear: after the primary treatment when the solids are removed, after the secondary treatment once most of the organic matter has been removed, and the centrate from anaerobic digestion, which contains high nutrients concentrations [4]. Although all these wastewater types contain the main nutrients needed for microalgae growth, their concentration affects growth rate and varies the productivity of the process. In Figure 2, the oxygen production by microalgae-bacteria consortia is evaluated using primary wastewater (Figure 2A), secondary wastewater (Figure 2B) and centrate (Figure 2C) in spring season according to the nutrient concentrations presented in [4]. Using the biological models along with the environmental real data and wastewaters composition, it is possible to evaluate the potential oxygen production, which is strongly affected by the nutrients present in the effluents. Looking at the oxygen reduction that happens when high nutrient concentration effluents are used (such as centrate) a potential growth inhibition caused by an excess of ammonium or others micropollutants is observed. A solution to face this disadvantage is to dilute the effluent before use.



(A) Primary wastewater



(B) Secondary wastewater



(C) Centrate

Figure 2. Biological models for different wastewaters data to demonstrate the nutrient concentrations effect on the productivity of the microalgae systems: (A) wastewater from primary treatment; (B) wastewater form secondary treatment;(C) centrate from anaerobic digestion.

This new interactive tool based on biological models is not only proposed for understanding these processes, but also a possible solution to predict the productivity of microalgae-bacteria system and consequently, to avoid long experiments, waiting time, and additional costs.

This work has been partially funded by the following projects: DPI2017 84259-C2- 1-R (financed by the Spanish Ministry of Science and Innovation and EU-ERDF funds), the European Union's Horizon 2020 Research and Innovation Program under Grant Agreement No. 727874 SABANA and the PURASOL project CTQ2017-84006-C3-3-R (financed by the Spanish Ministry of Economy and Competitiveness) . As well as being supported by the Spanish Ministry of Education through the National FPU Program (grant number FPU16/05996).

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PH.D. THESES

Mass-balance-based experimental design and data reconciliation for wastewater treatment processes

PhD thesis by Quan Le (HongQuan.Le@UGent.be), public defence on 01/10/2019.

URL PhD dissertation

Institution

Ghent University

Supervisors

Prof. dr. ir. Eveline Volcke

Faculty of Bioscience Engineering, Ghent University

Abstract

In wastewater treatment plants, a lot of data are collected in view of performance monitoring, plant control, for retrofit purposes as well as for process modelling. Setting up a suitable data collection strategy and checking the reliability of the collected data are essential but complicated and time-consuming challenges. Mass balancing is one of the most common types of calculations performed by process engineers in designing a new process or analysing an existing one. However, how can we systematically use this tool to address the problem of data quality in a wastewater treatment process? In this doctoral research work, mass-balance-based data reconciliation is applied to get more out of the data collected at wastewater treatment plants, both in terms of data accuracy as well as information content.

A mass-balance-based experimental design procedure for data collection was developed to guarantee that monitoring campaigns effectively meet their goal in identifying key variables and guaranteeing the quality of collected data. The possible data collection strategies proposed by the procedure were represented in a Pareto-optimal front, which represents a trade-off between accuracy and cost. The added value and general applicability of the procedure were demonstrated in five full-scale case studies to comparing its results to the outcome from the alternative approaches from the literature.

A structured and practical procedure for the application of mass-balance-based data reconciliation, i.e., the actual reconciliation of the key variables, was set up as well. Methodological aspects of data reconciliation were tackled by comparing conventional data reconciliation based on linear mass balances to an alternative approach based on bilinear mass balances. The advantages of the latter were demonstrated, in terms of essential performance indicators, for a full-scale case study. Finally, data reconciliation was also applied to a dynamically-operated system. Overall, the results demonstrate good potential for increasing the amount of information obtained from wastewater treatment process data by applying mass-balance-based data reconciliation.

Monitoring, understanding and modelling of a biofilm-based technology to increase the capacity of aerated lagoons

PhD thesis by Bernard Patry (bernard.patry.1@ulaval.ca), public defence on 24/04/2020.

URL PhD dissertation

Institution

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Prof. Paul Lessard. Université Laval.

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Abstract

Aerated lagoon (AL) systems are widely used for wastewater treatment in small communities of Canada and the United States. In the province of Québec, for example, more than two thirds of all plants are of this type. Among the plants classified as small or very small (yearly average flowrate below 2500 m³/d), this fraction rises to 85%. With, on the one hand, the evolution of regulations imposing increasingly strict discharge standards for treatment plants and with, on the other hand, the growth of the served communities, the upgrading of many AL type plants is becoming a necessity.

One of the solutions put forward for increasing the capacity of AL is to add a fixed biofilm support within the lagoons to increase the biomass retention time as well as their concentration. This solution has been adopted by the Quebec company Bionest by developing the KAMAK™ technology. The main idea of the KAMAK™ is to add a fixed bacterial support within aerated columns installed directly in the lagoons. These columns, installed in series, form biofilm reactors within the lagoons. The complete KAMAK™ system consists of an alternation of sedimentation zones (3) and biofilm reactors (2). This thesis aims at increasing the knowledge of this type of technology which was poorly documented so far.

An online water quality monitoring strategy was deployed on a full-scale KAMAK™ system installed in a portion – to simulate an overload situation – of the AL of the small Quebec municipality of Grandes-Piles (415 inhabitants). This high-frequency monitoring made it possible to gain an understanding regarding the installation, operation and maintenance of automated monitoring stations in the context of a small system without day-to-day operation and, of course, to collect data to objectively assess the performance of the studied system. A data treatment procedure was developed to transform raw data into more easily interpretable data and, ultimately, into input files for process modelling.

Interpretation of the monitoring data allowed assessing the performance of the technology. The performance analysis focused on the main challenges identified for the system, namely nitrification and total suspended solids (TSS) removal. For nitrification, the data have shown that the system allows extended seasonal (at warm temperature) nitrification compared to typical AL systems (suspended growth), and even with the system being exposed to higher organic loading rates. The extension was mainly observed in the fall, at the end of the optimal nitrification period. However, during the summer period, a temporary nitrification loss event was experienced. The explanation for this event is connected to the second challenge: TSS removal. Indeed, TSS present in the system was correlated with this event and with the operating temperature.

Monitoring of solids accumulation and sediment digestion helped identify potential causes for the poor TSS removal performance in this period. The evolution of sediment height, sediment characteristics and gas production associated with their digestion, was monitored in parallel to the monitoring of water quality. It

showed that the high loading rate conditions applied to the system are associated with sediment accumulation during winter followed by their anaerobic digestion during the summer period. The resulting production of biogas caused sediment resuspension. This resuspension phenomenon has been used to explain the momentary deterioration in effluent quality in terms of TSS and ammonia during the summer period. Regarding nitrification, an increased attachment of TSS to the biofilm, associated with a lower penetration of oxygen, led to a decrease in the activity of the nitrifying bacteria.

In order to understand the performance of the system in a comprehensive manner and to validate the presented explanations for the momentary deterioration of performance, a mathematical model was developed to describe the complete system. The modelling work highlighted the complexity of the nitrification performance dynamics and illustrates, in an integrated manner, the existing links between the different active processes within the system. Innovative features were integrated in the model to describe the resuspension of sediment and the influence of temperature on autotrophic bacteria. Two groups of autotrophic bacteria had to be considered in the model to adequately describe the observed nitrification performance. The model was finally used to assess the impact of new operational strategies and configuration changes on the performance of the system.

Modelling of Suspended Solids in Integrated Urban Wastewater Systems – Reliable and Efficient Data Collection, Modelling and Optimization

PhD thesis by Julia M. Ledergerber (julia-margrit.ledergerber.1@ulaval.ca), public defence on 22/01/2020.

URL PhD dissertation

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Abstract

The advantages of integrated water management have been known for decades, but are more than ever important. This is acknowledged in goal six of the 17 sustainable development goals of the United Nations. By targeting both clean water as well as sanitation, this goal is inherently asking for an integrated approach since it recognizes their interdependence. This dissertation aims at advancing the field of integrated water systems modelling in general, and in particular with respect to suspended solids. Overall emissions from the integrated urban wastewater system have gained interest since water quality standards are increasingly extended from the water resource recovery facility to the sewer system. Integrated modelling allows evaluating interactions and estimating overall emissions complementary to the not (yet) abundant water quality measurements. For this evaluation suspended solids can be seen as an indicator for the receiving water quality covering particulate pollution as such, but also undesired organic matter, nutrients and substances such as hydrophobic micropollutants. The modelling approach chosen is conceptual, due to its rapid calculations, and based on the particle settling velocity distribution wherever settling and resuspension are the characteristic processes of suspended solids. The approach is extended with complementary models to cover the integrated system from the catchment down to the water resource recovery facility.

The development of an integrated model however requires vast data sets. First, for efficient data collection a procedure is established to build a fast conceptual sewer model from its detailed hydraulic counter part. Second, an optimal experimental design methodology is adapted to the challenging sewer environment for the efficient planning of a water quality measurement campaign. The usability of the particle settling velocity approach is then shown by calibrating and validating the model for a case study. A procedure is developed to consider parameter uncertainty and input variability to identify reliable control handles. The procedure is applied for the abatement of total suspended solid, facilitated by the comparably low computational demand of the model, as the procedure asks for multiple global sensitivity analyses. The last chapter closes the dissertation with the practical application of evaluating different strategies to reduce the total suspended emissions to the receiving water. The dissertation thus advances the field of integrated modelling for particulates and at the same time provides procedures which overcome barriers general to modelling focusing on reliable and efficient data collection, as well as optimization.

Characterization and modelling of grit chambers based on particle settling velocity distributions

PhD thesis by Queralt Plana (queralt.plana.1@ulaval.ca), public defence on 08/05/2020.

URL PhD dissertation

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Abstract

Grit chambers can be found at the headworks of most water resource recovery facilities (WRRFs) to protect equipment and the processes downstream and maintain the performance of primary and secondary treatments. Even though they play a crucial role, there is a lack of knowledge on grit characteristics and grit chamber behaviour and modelling. This leads to an improper grit definition, a non-existing standard protocol of sampling and characterization, a non-existing standard protocol to evaluate the performance of the system and only simple models based on a static %-removal.

Given the fact that particle settling is the governing process of grit particle removal, that a vast diversity of sampling and characterization methods is existing, and modelling has been limited to very simple static %-removal based equations, two main objectives in the context of this study are pursued.

The first objective aims for a characterization method taking into account the key parameter of the settling process, i.e. particle settling velocity. It is divided in multiple sub-objectives. First, the establishment of a site-specific sampling protocol to obtain representative samples from the water around the studied grit chambers. Then, the currently used methods to characterize grit particles and wastewater are compared and adapted prior to the proposal of a characterization method.

The second objective of this study is to present a new dynamic model based on particle settling velocity distributions (PSVD). The model is tested on two different case studies with different grit chamber designs (vortex and aerated) and treatment capacities. In both cases, the model was successfully calibrated and validated using time series of turbidity data collected at a full-scale grit chamber. Thus, a powerful model is obtained to predict the solids concentration at the outlet and solids removal at the underflow (i.e. grit particles) of a grit chamber depending on the inlet dynamics.

Summarizing, the results of this PhD study are a new experimental characterization and, for the first time, a dynamic model based on PSVD. Both new tools have been successfully tested at full-scale.

Control of an integrated wastewater systems based on water quality: Towards fault-tolerant strategies

PhD thesis by Sovanna Tik (sovanna.tik.1@ulaval.ca), public defence on 05/03/2020.

URL PhD dissertation

Institution

model*EAU* – Université Laval

Supervisors

Prof. Peter A. Vanrolleghem. model*EAU* – Université Laval

Peter.Vanrolleghem@gci.ulaval.ca

Prof. Paul Lessard. Université Laval

paul.lessard@gci.ulaval.ca

Abstract

Regulation concerning urban wastewater management is evolving towards a holistic approach which leads stakeholders to increasingly consider the integrated urban wastewater system (IUWS), including the sewer system and the water resource recovery facility (WRRF), as a whole. This change of paradigm opens doors to new collaborations between the traditionally separated fields of urban drainage and wastewater treatment operation and research. In this context of innovation and integration, modelling is going to be a key tool, granting a better understanding of the complexity of interactions between the different parts of the IUWS. At the same time, the IUWS has to become more resilient to face the impacts of climate change, the long-term effects of which are difficult to quantify. Still, climate change experts agree on the increasing probability of occurrence of high intensity rain events, reaching the limits of current wastewater infrastructure operational capacities. In order for these infrastructures to continue to provide adequate performance with respect to current norms and regulations, while limiting costs and budgetary needs, flexible solutions, such as implementing real-time control (RTC) systems, should be considered. Especially since recent technological developments bring new and more reliable tools to measure water quality, and also to analyse and manage large quantities of data. This study focuses on the behaviour of the particulate pollution in the IUWS, an important water quality indicator, commonly measured as the total suspended solids (TSS) concentration and highly correlated with turbidity measurement. As turbidity sensors are readily available with increasing reliability, their operational use can be envisioned. The objective of this thesis is to develop and assess water quality-based control strategies for the IUWS. An integrated - sewer and WRRF - model, using the particle settling velocity distribution (PSVD) approach, has been proposed. This approach improves the description of particle settling and resuspension in the whole system, allowing a better forecast of TSS concentration dynamics, especially during rain events. Based on this integrated model, innovative water quality-based control strategies, aiming at reducing overall discharge of particulate pollutants (and the heavy metals, pathogens, etc. that come with it) to the receiving water during wet weather, have been proposed and successfully tested. Experimental studies demonstrated that turbidity sensors installed in the IUWS are subject to harsh conditions, leading to faulty sensor signals. The performance loss due to the use of water quality-based control strategies affected by a faulty turbidity signal has been evaluated in detail and this has demonstrated the need for fault detection tools. When a faulty signal is detected, alarms will allow operators to decide which operating mode should be used instead of the one using the now faulty sensor. Alternatively, automatic responses and changes could be implemented to counteract the effects of a faulty signal. This last option, called downgraded operating mode, which implies reverting to a control strategy that does not use the faulty signal, has been simulated and tested. If the fault is detected within reasonable time (which depends

on the system dynamics), these simulations have shown that part of the increase of performance gained with the water quality-based strategy using the good signal, can be maintained. The results of this study thus present a strong case for optimizing wastewater infrastructure operations, especially when they are considered as an integrated system, instead of autonomous and mutually exclusive systems. Furthermore, the developed integrated model may be use as a decision support tool to help determine the best possible (integrated) control strategy.

Digital Water Programme: IWA Digital Water Summit

IWA launched a Digital Water Programme to support utilities and all IWA members to embrace the opportunity of digital tools through sharing experiences, inviting non-water stakeholders to contribute and co-create future solutions to water challenges.

The IWA Digital Water Summit is designed to be the reference in digitalisation for the global water sector. Targeting all stakeholders involved in the water sector digitalisation, the Summit has a focus on business and industry. Water technology providers and water utilities are the main participants that will discuss and shape the agenda of this first edition. Co-organized by the water utility in the region (Consorcio de Aguas Bilbao Bizkaia) and the IWA Governing Member in Spain (AEAS). The IWA Digital Water Summit will be held in Bilbao, Spain from November 30th to December 3rd. Further information on the IWA Digital Water Summit can be found here.

For more information, contact Oliver Grievson, our ICA SG-MC representative within the Digital Water Programme.

On Demand Webinar: Perspectives on Smart Stormwater Networks

Stormwater network management is a crucial issue for the preservation of the global natural environment as well as the safety of life and properties in urban areas. Using smart systems and advances in information and communications technology it is possible to upgrade the conventional management approaches into innovative and efficient systems. This webinar will provide an overview on technical (and non-technical) motivations and barriers to using digital technologies in sewer systems. Moreover, social challenges will be presented on multiple levels: individual, organisational and institutional.

The On Demand Webinar 'Perspectives on Smart Stormwater Networks' aims to achieve the following learning objectives: i) importance of digitalisation in stormwater management, ii) awareness of the importance of appropriate smart stormwater networks, iii) technological and social barriers of smart stormwater networks, and iv) overview on policy instruments to overcome existing challenges.

The webinar was hosted by Kris Villez and the International Water Association, and involved the following panellists:

- Oliver Grievson (Technical Lead at Z-Tech)
- Liliane Manny (PhD student at Eawag)
- Sonja Ostojin (Innovation Consultant at Environmental Monitoring Solutions)

You can enjoy the webinar 'Perspectives on Smart Stormwater Networks' for free here.

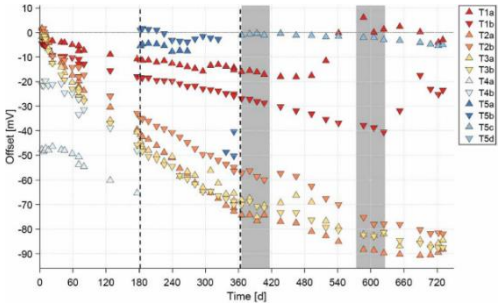
inCTRL Webinar Series

inCTRL has started a special webinar series focused on knowledge transfer during COVID-19 restrictions. The objective is to share inCTRL's special expertise on topics close to our heart.

The first three webinars already took place but are available on the inCTRL Solutions YouTube Channel.

Title	Date	Presenter
Make Your Aeration System Work! Detailed Aeration System Modeling in SIMBA#	2020-05-27 (recording available)	Oliver Schraa
Sensors Driving You Mad? - Selecting and Operating On-line Sensors	2020-06-17 (recording available)	Leiv Rieger
What Did I Just Feed my Digester? - A Practical Guide to Predictive Modeling of Multi-Feed Biogas Plants	2020-07-08 (recording available)	Alex Rosenthal
Garbage in knowledge out - Application of Advanced Data Analytics for WRRFs	2020-07-22	Ivan Miletic

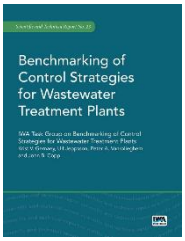
More on inCTRL digital offerings are published on the inCTRL website. For more information, contact Leiv Rieger.



MetaCO: IWA TG on organization of meta-data and sensor data quality

The IWA MetaCO TG (Meta-data Collection and Organization) is organizing monthly utility meetings among registered utility members of the MetaCO Task Group. Topics include sensor validation protocols, collection of meta-data, and methods for data validation. If you want to join the MetaCO task group or for more information, please contact Kris Villez or Janelcy Alferes.

IWA TG on Benchmarking of control strategies for wastewater treatment plants: download the Scientific and Technical Report for FREE



The IWA Scientific and Technical Report no. 23 on Benchmarking of Control Strategies for Wastewater Treatment Processes (Krist V. Gernaey, Ulf Jeppsson, Peter A. Vanrolleghem and John B. Copp (Eds).) is now freely available as open access. You can download the complete pdf file from here!

IWA WG on Good Modelling Practice: new TG proposal and upcoming course

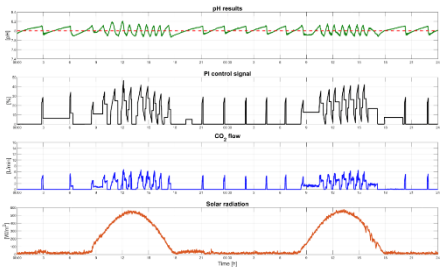
The IWA WG on GMP is working on a proposal for a new IWA Task Group on "Good Modelling Practices in Wastewater Resource Recovery Systems". This proposal is planned to be ready for submission to IWA before summer 2020.

The training course on "Modelling Activated Sludge Plants" planned for the EcoSTP 2020 conference has had to be postponed to 2021, as the IWA EcoSTP 2020 conference has been postponed to 21-25 June 2021 in consideration of the current sanitary situation.

For more information, please contact the GMP WG chair, Guenter Langergraber.

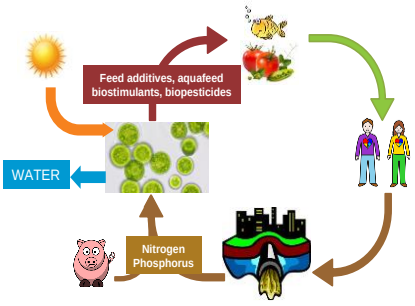
CALRESI PROJECT: Modelling and control of the combined process of microalgae production and wastewater treatment with industrial reactors

This project is funded by the National Plan Project DPI2017-84259-C2-1-R of the Spanish Ministry of Science, Innovation and Universities and FEDER funds. The project deals with the analysis, study and application of modeling and control strategies for the optimisation of the process of wastewater treatment and biomass production of microalgae in large scale industrial photobioreactors. The main objective is to achieve optimal work conditions that allow an efficient synergy of the combined process of optimal growth of microalgae and the wastewater treatment, trying to achieve an appropriate balance between the energy required for such a process, the injection of CO_2 for the maximization of microalgae production, and the recovery of costs through the resulting products. The appropriate combination of microalgae with waters residuals will allow to achieve an energy balance for this type of processes and, at the same time, contributing to the mitigation of emissions of gases to the environment. As well-known, the presence of microalgae, bacteria and organic matter make that such systems having a highly complex and non-linear dynamics. As a result, the main objectives of this project are: (1) Development and proposal of strategies of modeling, estimation and identification for the combined process of the production of microalgae and treatment of wastewater in raceway reactors; (2) Development and proposal of different control strategies for the efficient production of biomass and wastewater in order to contribute to the reduction of costs and environmental impact; (3) Implementation and validation of modeling and control strategies developed in two industrial large scale raceway photobioreactors.



For more information, please contact José Luis Guzmán.

EU Commission support the SABANA PROJECT devoted to the development of microalgae based biorefineries integrating wastewater treatment



This project was approved by the European Union's Horizon 2020 Research and Innovation program, under the topic H2020-BG-2016-2017 Blue Growth: Demonstrating an ocean of opportunities, under the Grant Agreement No. 727874. The challenge is to build and operate a demonstration facility for the production of biofertilizers and aquafeed at 5 ha scale integrating wastewater treatment. It provides a solution for three current key issues in the EU: (i) improvement of the safety and sustainability of food production in agriculture and aquaculture, (ii) contamination problems resulting from nutrients dissemination and scarcity (phosphorous), (iii) minimization of greenhouse gas emissions from wastes (wastewater and flue gases). The challenge is to develop robust technologies, accomplishing industrial standards, on the basis of adequate models, simulation and control technologies. On this project, the development of robust control technologies capable to optimize the performance of the under highly variable weather conditions is a challenge. The project is led by the University of Almeria but major actors are the companies involved in the project (FCC Aqualia, GEA Westfalia, A.I.A. S.p.A., Biorizon Biotech S.L.), in addition to high reputation research centers at EU level (Karlsruhe Institute of Technology, Mikrobiologicky Ustav, Universita Degli Studi Di Milano, Univ. Las Palmas de Gran Canaria, Szechenyi Istvan University, Consorzio Italiano Biogas e Gassificazione). In addition to 11 partners from 5 EU countries, Fundacion Cajamar and IFAPA also collaborate in this project.

For more information, please contact F. Gabriel Acien.

SPACE-O INTERNATIONAL PROJECT

SPACE-O Project integrates state-of-the-art satellite technology and in-situ monitoring with advanced hydrological, water quality models and ICT tools, into a powerful decision support system. This generates real-time, short- to medium-term forecasting of water flows and quality data in reservoirs, used to optimize water treatment plant operations and establish a complete service line from science to the water business sector. **Subscribe to the project newsletter.**

Project website: *http://www.space-o.eu/*

Water Industry Process Automation & Control (WIPAC)

The WIPAC Group was setup as a LinkedIn discussion group in May 2011 by its group manager, Oliver Grievson. The group has grown to an industry leading discussion group about the opportunities and issues surrounding the "digital" water industry including the subject areas of Data and its use, instrumentation and process automation & control (www.wipac.org.uk).

The group as a whole spreads the word about how the digital water industry is developing and the things that have worked through WIPAC Monthly which is a magazine that is produced by the group. WIPAC Monthly is distributed on a global basis using the LinkedIn platform and has quickly become a globally popular resource for Water Industry Professionals to pick up on the trends of the "digital" or "smart" water industry.

WIPAC is run by Oliver Grievson, the group manager as a not for profit organisation. Should you want to support the organisation in anyway by providing case studies, articles, press releases or papers for WIPAC Monthly then feel free to get in touch with the Group Manager.

PEOPLE ON THE MOVE – OPEN POSITIONS

Are you looking for an ICA professional in your company or institute? Feel free to send these vacancies to the Newsletter editor for announcement in the next issue of our Newsletter.

TRAINING AND EDUCATION

Are you involved in any Master or Post-Graduate course including ICA-related profiles? Feel free to send this information to the Newsletter editor for announcement in the next issue.

Training and education are a key need for the water industry. Specific training about control provides better capabilities in solving typical problems that appear in water treatment processes. However, there is a global shortage of engineers and engineering technicians; this has long been seen in the water industry as a whole. Most of the projects seldom include the participation of ICA engineers, which leads to inefficient choice of sensors and instruments. Plant design and control systems design have to work together. Too often the designers have not understood the ICA requirements and possibilities resulting in less flexibility and unnecessary costs. Consequently, process designers have to work together with control system designers, computer and communication engineers. These positions are in high demand as utilities and consulting companies increase staffing for the IoT revolution. Hence, the ICA-SG would like to promote any ICA-related course that could help to provide these qualified profiles to the water industry.

ICA-RELATED URLs

Associations
http://web.tiscali.it/RTCUSD
http://de.dwa.de/
http://www.instrument.org
http://www.ifac-control.org
http://www.isa.org
http://www.swig.org.uk
http://www.wef.org
http://esbes.org/M3C.html

Universities – Research Institutes
http://www.awmc.uq.edu.au
http://biomath.ugent.be
http://www.biosys.ugent.be
http://www.ceit.es
http://modelEAU.fsg.ulaval.ca
http://www.ifak.eu
http://www.montpellier.inra.fr/narbonne
http://sitios.iingen.unam.mx/lipata (in Spanish)
http://www.iea.lth.se
http://lequia.udg.cat http://calagua.webs.upv.es/en
https://krisvillez.gitlab.io/profile/
http://www.genocov.com

Modelling Software Companies
http://www.dynamita.com/
http://www.envirosim.com
http://simba.ifak.eu/
http://www.mikepoweredbydhi.com/
http://www.hydromantis.com/
http://www.inctrl.com/

Instrumentation Companies
http://www.applitek.com
http://www.danfoss.com
http://www.conducta.endress.com
http://www.endress.com
http://www.envirotech-online.com
http://www.hach.com
http://www.microlan.nl
http://www.product-search.co.uk
https://www.s-can.at/
http://www.systea.it
http://www.ysi.com/

Control and Automation Companies
http://www.bioprocesscontrol.com
http://www.kruger.dk
www.inCTRL.ca
https://rittmeyer.com
http://www.primodal.com/

Newsletters
http://www.omeda.com/wwr
http://www.wateronline.com/
http://www.wipac.org.uk/wipac-monthly.html

UPCOMING EVENTS

21st IFAC World Congress (1st Virtual IFAC World Congress) in Berlin, Germany, July 11-17, 2020

The IFAC 2020 National Organization Committee has proudly announced a first in the 63-year history of IFAC: The 1st Virtual IFAC World Congress (IFAC-V 2020). The IFAC-V 2020 National Organizing Committee and the International Program Committee will bring forward numerous new ideas and formats for securing quality and bringing a bit of the atmosphere of a real World Congress also to the virtual congress. Among the features are virtual opening and closing ceremonies, plenary talks, the IFAC Control Orchestra and social interaction possibilities. All with innovative live-elements during those hours of the day when the congress attendees all over the world are awake. For paper presentations, IFAC-V 2020 will ask to provide videos, which will be archived to be downloaded on demand.

This forum of excellence in control science and technology of the International Federation of Automatic Control (IFAC) showcases and allows to explore the frontiers in control science and technology and their applications.

For further information visit www.ifac2020.org.

7th IWA Water Resource Recovery Modelling Seminar - **WRRmod2020 is now WRRmod2021!**

Due to the COVID-19 outbreak, the 7th IWA Water Resource Recovery Modelling Seminar (WRRmod2020) has been postponed to 2021 and will be held in Arosa, Switzerland from August 21st - 25th, 2021. Abstracts for WRRmod2021 are welcome until February 1st, 2021. For more information, please go to the WRRmod2021 seminar website.

2nd International CCWI / WDSA Joint Conference in Beijing, China, September 1-4, 2020 - **POSTPONED to 2021!**

As the COVID-19 pandemic continues to evolve, the Local Organizing Committees have made the difficult decision to further postpone CCWI/WSDA 2020 to September-October 2021. More information about the conference will be updated on the website.

With a theme of Smart Water, the 2nd International CCWI (Computing and Control for the Water Industry) / WDSA (Water Distribution Systems Analysis) Joint Conference will examine the concepts, technologies and policies for building intelligent, green, safe and reliable urban water systems. World-leading academics and practitioners from the fields of infrastructure planning, modelling, optimization, asset management, ICA, data analytics, and regulation and policy will share and discuss strategies to support the creation and adoption of smart water infrastructures.

For further information visit the conference website or contact Shuming Liu.

15th IWA/IAHR International Conference on Urban Drainage (ICUD), 6-11 September 2020, Melbourne, Australia

The ICUD 2020 conference program will feature a range of stimulating presentations from keynote speakers, concurrent sessions, posters session, pre-conference workshops and technical tours. The comprehensive program will engage and inform delegates of the advancements in research on urban drainage.

The Conference Organisers and Committee are very conscious of the impact COVID19 is having on the world and will continue to monitor the situation closely following the advice of the Australian Government health officials and the World Health Organisation. The safety and well-being of all stakeholders is the first priority of the Conference Organisers and Committee. Should the sanitary situation impact the Conference, regular updates will be made to the website.

For further information visit the conference website.

Innovations in Process Engineering - New Tools, Technologies, and Techniques for Research, Design, and Operation Conference, June 8-11, 2021, Miami, Florida, USA

WEF is soliciting submissions for abstracts, workshop proposals, and session proposals for its newest conference Innovations in Process Engineering - New Tools, Technologies, and Techniques for Research, Design, and Operation Conference to be held June 8-11, 2021, in Miami, Florida.

Designed to serve as the cutting-edge showcase for the introduction and discussion of new practices for water resource recovery facilities; this conference will concentrate heavily on research, development and innovation.

Please click this link for all the details.

IWA SG CONFERENCE

The 13th IWA Conference on Instrumentation, Control and Automation - ICA2021, 12-16 September 2021, Beijing, China.

The 13th IWA Conference on Instrumentation, Control and Automation will be held in Beijing, China, 12-16 September 2021. ICA2021 will bring the conference home to Asia once again and will be the first ICA conference in China. ICA2021 will be hosted by Tsinghua University. Prof. Zhiguo Yuan and Prof. Hanchang Shi are the Chair of ICA 2021.

The ICA conference series has always been a milestone in moving the water industry forward towards more efficient and more robust operation and to help improve the quality of our waters. ICA2021 will attract considerable interests and support from the water industry, academic institute and consultant organizations worldwide, which will provide an excellent platform for in-depth communication among scientists, professionals, and academia in different areas of the broader theme of environmental sciences and engineering.

If you would like to be a sponsor or exhibit in the conference, you are very welcome to contact us. We anticipate your participation in the Conference. It is a great pleasure to invite you to Beijing (China) for the 13th IWA Conference on Instrumentation, Control and Automation. For further information contact Dr. Yanchen Liu.

Other upcoming conferences including ICA-related sessions and workshops

Nutrient removal and recovery conference (VIRTUAL CONFERENCE), 01-03 September 2020, Espoo, Finland, www.iwa-nrr.org

IWA World Water Congress & Exhibition: Water for smart liveable cities, 9-14 May 2021, Copenhagen, Denmark, worldwatercongress.org

Wastewater, Water and Resource Recovery, 16-19 May 2021, Poznan, Poland, wwrr.put.poznan.pl

5th International Conference on Ecotechnologies for Wastewater Treatment, 21-25 June 2021, Milano, Italy, www.ecostp2020.polimi.it

NEWS FROM IWA HEADQUARTERS

COVID-19: The post-pandemic outlook for water utilities
Water and wastewater utilities provide essential services – the good management of these resources saves lives. This global health crisis has put a special spotlight on water utilities and they are managing the crisis with innovative solutions and high ethical standards.

World Environment Day: Nature for Water and Sanitation Resources
World Environment Day 2020. This is the most renowned day for environmental action. Since 1974, it has been celebrated every year on 5 June; engaging governments, businesses, celebrities and citizens to focus their efforts on a pressing environmental issue.

Rik Thijssen: Digital Water business models
The digital transformation presents new business opportunities for the water sector. Listen as Rik Thijssen, Manager of Business Development at Vitens, gives his thoughts on them as well as the ways in which digitalisation can help overcome challenges in the organisation.

Vladan Babovic: Data Privacy
One of the biggest concerns about the digital water transformation is privacy. How can utilities ensure that the customers data remains confidential? Who protects it from being stolen or used for the unethical gain? Professor Vladan Babovic, believes it's the duty of the IWA Digital Water Programme to highlight the right technology in the right context.

Decarbonisation and Digitalisation
The Marselisborg Wastewater Treatment Plant is not the typical WWTP you expect. It’s an old facility that cleans the wastewater generated by about 200, 000 people. But the plant is a climate marvel: it receives no sources of external carbon and neither is it powered by renewable energy.

New dates for IWA World Water Congress & Exhibition
Due to the unprecedented impact of the COVID-19 pandemic, the IWA World Water Congress & Exhibition is being postponed and will now take place on 9-14 May 2021. It will still be held in the wonderful city of Copenhagen.

Cecilia Wennberg: Digitalisation journey for the water utility value chain
The digitalisation of the water sector allows for improved management of water utilities as well as prompt communication with consumers. In her interview, Cecilia Wennberg, Vice President of Market Development at DHI, talked about the benefits of technological advancements in the water sector.

What does COVID-19 mean for WASH and Vulnerable Communities?
Imagine being in the middle of a pandemic with no access to safe sanitation or clean drinking water, and no room for personal space. What do you do when 2 of the most useful measures of prevention are regular hand-washing and social distancing? Vulnerable communities face this daunting reality amidst this COVID-19 pandemic while trying to reduce the possibility of infection.

Regulators – a joint response to face the COVID-19 crisis
Regulatory agencies are at the forefront of making sure citizens and industry have access to fundamental services. They operate in a context of increasing complexity, technological disruption and constrained resources and in these days water regulators work in a critical health area of our societies.

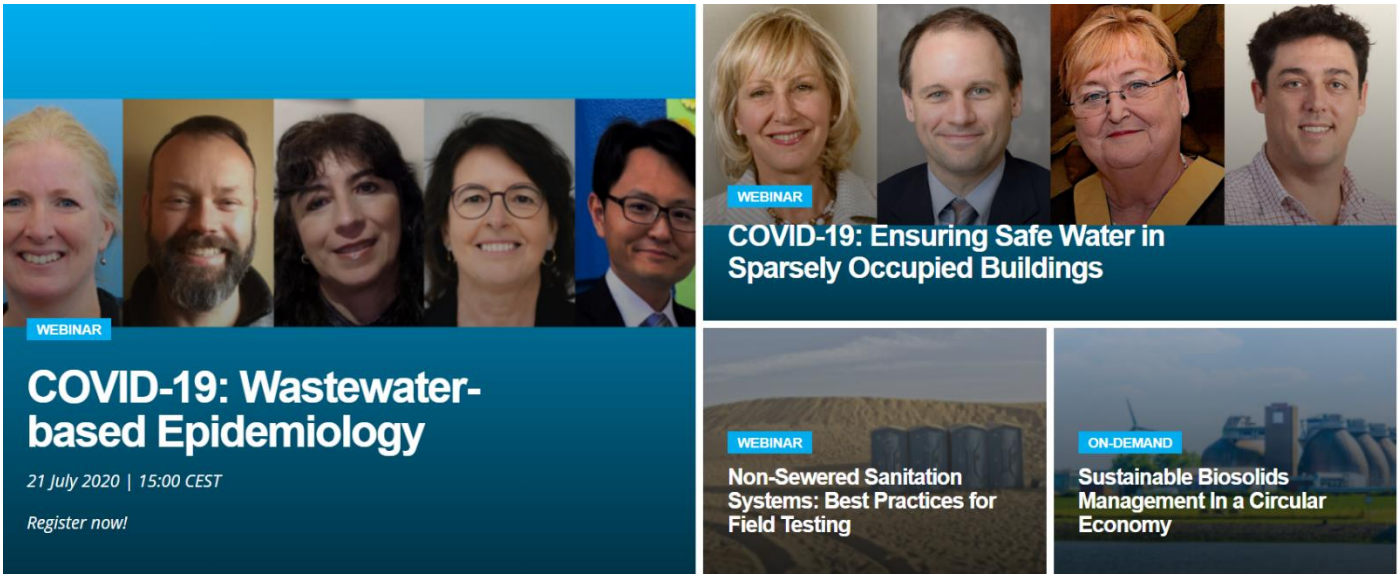
Utility Insight into the COVID-19 Pandemic
Worldwide, water and wastewater utilities provide essential services. Regular and thorough hand washing is one of the basic protective measures advised by the World Health Organization (WHO) against COVID-19. But also for any other household activity, safe drinking water and sanitation services are critical.

A Technical Perspective on COVID-19
The COVID-19 (SARS-CoV-2) pandemic is raising many questions for the water sector around the world. While operators provide their services within a national context, scientific and operational concerns and insights are relevant across borders.

[Information resources on water and Covid-19]

The Covid-19 (SARS-CoV-2) pandemic is raising many questions for the water supply and wastewater sector around the world. This includes the public seeking reassurance about potential concerns. The organisations who provide water and wastewater services have to respond to this and cope with the direct impact of the pandemic on their workforces.

IWA Learn

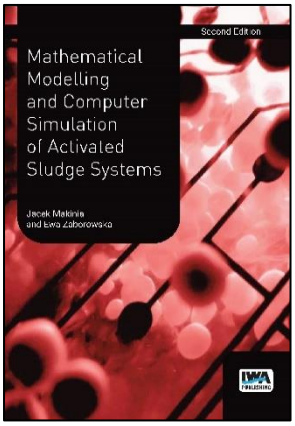


The place for learning & professional development in the water sector

Professionals in the water sector require continuous development to be able to stay abreast with the changing environment circumstances. No matter in which stage of your career, IWA provides you with guidance and opportunities to build up the competences required to succeed. This includes a set of tools on how to develop your career, as well as opportunity of professional updating, learning, training and networking.

To learn more, visit the IWA Learn platform: https://iwa-network.org/iwa-learn/

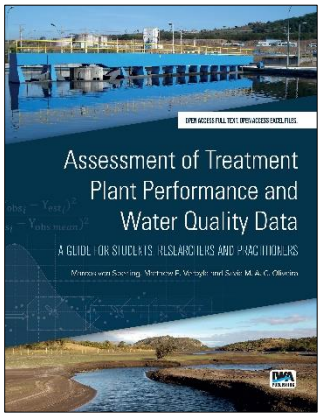
Selected books



Mathematical Modelling and Computer Simulation of Activated Sludge Systems - Second Edition

Authors: Jacek Makinia and Ewa Zaborowska
ISBN: 9781780409511
February 2020 • 670 Pages • Paperback
IWA Members price: £109.00 / US$ 164.00 / €136.00
https://www.iwapublishing.com/books/9781780409511/mathematical-modelling-and-computer-simulation-activated-sludge-systems-second

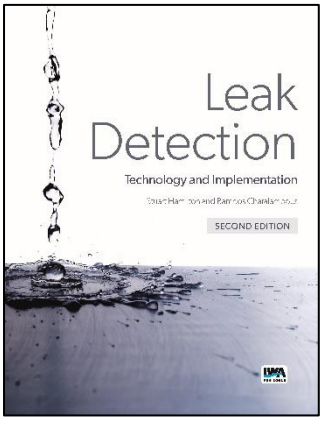
By combining a general introduction and a textbook, this book serves both intermediate and more experienced model users, both researchers and practitioners, as a comprehensive guide to modelling and simulation studies. The book can be used as a supplemental material at graduate and post-graduate levels of wastewater engineering/modelling courses.



Assessment of Treatment Plant Performance and Water Quality Data: A Guide for Students, Researchers and Practitioners

Editors: Marcos Von Sperling, Matthew E. Verbyla and Sílvia M. A. C. Oliveira
ISBN: 9781780409313
Open Access eBook
January 2020 • 640 pages • Paperback
IWA Members print price: £ 26.00 / US$ 39.00 / € 33.00
https://www.iwapublishing.com/books/9781780409313/assessment-treatment-plant-performance-and-water-quality-data-guide-students

The major concepts are illustrated by 92 fully worked-out examples, which are supported by 75 freely-downloadable Excel spreadsheets. Each chapter concludes with a checklist for your report. If you are a student, researcher or practitioner planning to use or already using treatment plant and water quality monitoring data, then this book is for you!



Leak Detection: Technology and Implementation

Author: Stuart Hamilton and Bambos Charalambous
ISBN: 9781789060843
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https://doi.org/10.2166/wst.2020.298

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