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50 years of design and operation of large wastewater treatment plant conferences. A history of innovation and development

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ABSTRACT

Large wastewater treatment plants (>50,000 population equivalents) treat more than 80% of the wastewater treated on a global scale, today it might be even >90%. They therefore provide the most relevant contribution to water protection from urban and industrial wastewater. This was already the case in 1971 when academics realised that progress in the scientific community alone will not succeed in a rapid transfer of research results to practitioners in design and operation of these plants. At the same time, it was recognised that urgent problems in practice are not recognised early enough by the globally networking scientific community. The most effective means of solving these problems was the creation of a new forum where experts from both sides meet. Scientists normally create their special conferences and workshops to enhance global co-operation in their specific field of research and development. This is reflected in the existence of many IWA Specialist Groups (SG) with global representation. The IWA Large Wastewater Treatment Plants (LWWTP) events and the formation of the LWWTP Specialist Group have been the first to take care of a complex technology for water protection, where specialists from most other SGs can meet and discuss together with the practitioners designing and operating treatment plants. In fact, many new Specialist Groups had their origin in the workshop series starting in 1971 in Vienna, taking care of many specific problems reported from practice. The managers and chief operators of large plants, usually only served by meetings of national professional associations, got a new opportunity for global exchange of knowledge and experience together with the global network of scientists and researchers.

Key words: development of wastewater treatment, history of wastewater treatment, large wastewater treatment plants

HIGHLIGHTS

- The IWA specialist group on Design, Operation and Costs of LWWTPs has supported technical development and innovation in the field since the 1970s.
- The specialist group provides the international network and suitable platforms to connect practitioners and researchers from around the globe.
- The conferences are providing the rapid transfer of research results to practitioners to solve urgent problems in practice.

THE START OF THE IAWPR (IWA) WORKSHOPS ON DESIGN-OPERATION INTERACTIONS AT LARGE TREATMENT PLANTS IN VIENNA IN 1971

The rapid recovery of the economy after World War II resulted in an increased wastewater production. Since the treatment was inefficient – in most cases direct discharge or only mechanically treated – receiving waters deteriorated. This caused increased action against pollution, and research on how to handle the problem started in many countries on a national basis. Only slowly, international cooperation started. In the UK, the country where historically wastewater treatment had a long tradition and many plants with biological treatment were operating, it was Sam Jenkins (IAWPR 1982) who initiated international contacts with institutions and colleagues active in water research like the USA, Germany, France, Japan, the Netherlands, South Africa, and others. His activities led finally to the foundation of the International Association on Water Pollution Research (IAWPR). The international exchange could be optimized by meetings of involved researchers in scientific conferences, the organisation of which was the main activity of the new organisation. The first of this conference series, later known as the IAWPR-Biennial Conferences, took place in London in 1962, followed by Tokyo in 1964, Munich in 1966, Prague in 1969 (postponed from 1968 because of the invasion of Warsaw-Pact troops), and San Francisco in 1970.

Within these biennial meetings, researchers from all over the world came together for one week to exchange research results, which were afterwards published in WATER RESEARCH, the main publication of IAWPR, which started in 1966. These conferences had a very high scientific level, and many important developments were published; for example, Downing *et al.* (1966) Nitrification in the Activated Sludge Process, which is still one of the most important basis for nitrification in biological wastewater treatment. However, the transfer of these results to practical application did not take place, or only after a long delay.

Two professors, W. Von der Emde and J.F. Andrews (Figure 1), both members of IAWPR, created the idea of establishing a new type of meeting called a 'workshop' with the intention of bringing researchers and practitioners into a productive discussion, resulting in a win-win situation for both.

W. Von der Emde developed some of the most important design criteria for the activated sludge process in his thesis at TU-Hannover (v. d. Emde 1957), went to practice at the sewer department of Hamburg and started teaching at the international courses for Sanitary Engineering in Delft. In 1964 he was appointed as professor for Sanitary Engineering at the Civil Engineering Faculty of Vienna University of Technology (TU Wien). He was one of the founders of IAWPR and since 1966 its Vice President, showing his international reputation and network. One of his favourite ideas was to enhance the transfer of research results into practice. On his way to the San Francisco conference in 1970 he visited Clemson University (South Carolina, USA), where one of the authors of this paper was making his postdoc with J.F. Andrews, professor of Environmental Systems Engineering department. During this visit they decided to start with a first Workshop in Vienna.

The aim of this Workshop should be to exchange knowledge, experiences and research results in design and operation of LWWTP on an international level. The topics should not be restricted to wastewater treatment processes, but to all problems and developments related to treatment plant design and operation. They should include, for instance, the influence of automation on design and operation as a highlight. The Workshop should also become a driving force for the scientific, technological and operational development of all aspects of wastewater treatment on a global scale.

The first consequence of the ideas presented above was the IAWPR Vienna Workshop at TU Wien in September 1971. About 130 participants from 22 countries, many of them from overseas (USA, Japan, South Africa) attended. Respectively, about 25% of the participants were operators, designers, researchers, and equipment suppliers. Representatives from large treatment plants in Berlin, Chicago, Hamburg, Johannesburg, London, Los Angeles, Philadelphia, Sheffield, Tokyo, and Vienna participated. Experts from national Water Associations from USA, Germany, UK, Israel, Japan and Sweden, design engineers from the big design companies from USA and Europe and scientists from USA, UK, Germany and Austrian research institutions completed the audience. Table 1 presents an overview of the number of participants in the first workshops in Vienna. Table 2 provides statistics of the presented papers referring to the countries of the speakers.

From the great success as a general reaction to the 1st Workshop – which was also the first of such specialized meetings in the framework of IAWPR (the precursor of IWA) – it was concluded to continue this event, which is now celebrating its 50th anniversary. After a period of four years, it was decided to continue this fruitful exchange with emphasis on presenting new

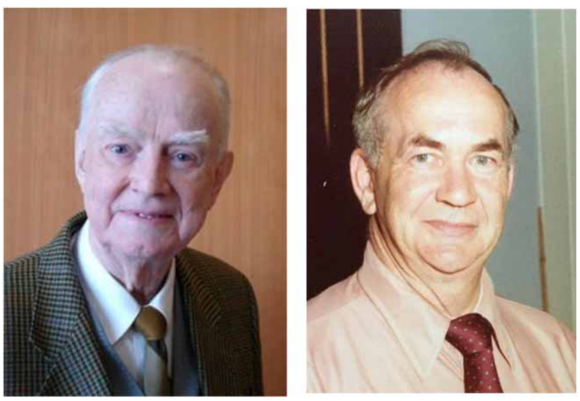

Figure 1 | Professors W. Von der Emde and J.F. Andrews.

Table 1 | Statistics of the participants of the first Vienna Workshops

	1971	1975	1979	1983
Participants	130	133	155	148
Countries	22	22	26	25
Papers	71	42	60	46

Table 2 | Statistics of the presented papers referring to the countries of the speakers

	1971	1975	1979	1983
USA	19	8	10	6
Germany	19	5	13	20
UK	12	7	20	8
Austria	9	5	4	1
Switzerland	2	3		2
France	2		1	1
Japan	2		1	2
Netherlands	4	3	2	
Poland	1	1		
Bulgaria			1	
Kuwait			1	
Syria			1	
Israel	1	2	2	
Sweden		1		5
Denmark			1	1
Finland			1	
Canada		4		
Turkey		1		
South Africa		2	2	
Papers/countries	71/10	42/12	60/14	46/9

developments on the one hand, and on reporting the results of full-scale application of information presented at the 1st Workshop on the other hand. The concept to devote about 50% of the time in the lecture hall for discussion and exchange of practical experiences was very positively recognized by the participants. It was decided to maintain it for future meetings.

Since more than 50% of the participants originated from non-English speaking countries, the written contributions were also available in German, and during the sessions a summary of the presentations in German was given by H. Fleckseder and R. Kayser. This translation service was also helpful during the discussions (the simultaneous translation service in English, German and French that was practiced till 1980 at the IAWPR-Biennial Conferences would have been far too expensive). Another feature of the Workshop was very much acknowledged by the participants. The social events with the typical Viennese atmosphere contributed to the positive effect on the human relations during the whole event.

The first Workshop was extraordinarily successful, and it was decided to continue this new type of scientific-technological meeting every 4 years. In 1971, the emphasis of the 71 papers presented was sludge treatment and disposal (18) and automation and control (12). Concerning aeration in the activated sludge process, the Carrousel (Koot & Zeper 1972) and Mammoth Rotor (Stalzer & von der Emde 1972) were dealt with. New aeration control concepts with the application of dissolved oxygen probes and the monitoring of oxygen uptake rates were presented (Brouzes 1972a, 1972b; von der Emde & Schopper 1972; Wheatland 1972). The elimination of nitrogen with a three-sludge concept at Lake Tahoe (Barth 1972) and a single sludge process with simultaneous nitrification-denitrification at Vienna Blumental (Matsché 1972) was demonstrated. The first practical experiences with P removal were reported from Switzerland (Wildi 1972). For the dewatering of sludges, the results of belt press, filter press and centrifuge were presented. Many big cities used sea disposal for their sludge (New York, Philadelphia, Los Angeles) or land application in Chicago (Lynam *et al.* 1972) and Niersverband (Kugel 1972), a topic of intensive discussion. Sludge incineration was only reported from Sheffield (Tench 1972). Another interesting highlight was the presentation of the first continuous monitoring instrument for organic pollution with a TOC analyser (Bleier 1972).

THE VIENNA WORKSHOPS UNTIL 1983

The 1975 Vienna Workshop started with environmental politics and the problems of effluent- and receiving-water standards (9 papers). A main topic was the problem of sludge bulking. The identification of the filaments was presented by Eikelboom (1977) and the recent research results of Chudoba *et al.* (1973) were successfully applied in a pilot plant for Vienna Main Treatment Plant (Kroiss & Ruider 1977). An improved aeration control system was applied at the Vienna Blumental TP (Usrael 1977) for the optimisation of N removal by simultaneous nitrification-denitrification at this plant (Matsché & Spatzierer 1977). Biological removal of P was for the first time observed in treatment plants in South Africa (Nicholls 1977), which was one of the leading countries in water research and reclamation at that time. Another new development was the contact filtration process from Switzerland. In contrast to this complicated process, the simultaneous precipitation of P with ferrous sulphate in Sweden was shown. The application of pure oxygen was dealt with in four presentations, a typical example for a technique that could not fulfil the expectations later. This applies to the deep shaft process as well (Bolton & Ousby 1977). The application of thermophilic digestion was for the first time applied in Los Angeles (Garber 1977).

The 1979 Workshop for the first time dealt with odour development and avoidance. The importance of catchment control to avoid toxicity of industrial effluents was discussed. Successful applications of the selector for bulking prevention were reported by Stalzer (1980) for a joint treatment of cannery and municipal wastewater at Wulkatal treatment plant, and by Kroiss (1980) for a large beet sugar wastewater treatment plant. For the removal of N, a new development was reported from Denmark by the alternating operation of two aeration tanks (Jes La Cour & Behrens 1980). The application of the experiences of Vienna Blumental WWTP were reported from Israel, where the process was applied for the Tel Aviv region (Goldstein 1980). New results for biological nutrient removal were reported from South Africa (Barnard & Pybus 1980).

The Workshop 1983 was dedicated to the remembrance of Sam Jenkins (IAWPR 1982), who passed away that year. As in the previous workshops, aeration, nutrient removal and sludge treatment were again the highlights. Characterisation of bulking sludge by measuring the length of filament were reported by Jenkins and Matsui, a method that was later abandoned. However, for the first time, severe problems with Nocardia scum were reported (Hiraoka & Tsumura 1984). Reports from Scandinavia with successful nutrient removal (Bundgaard & Kristensen 1984; Hultgren & Hultan 1984; Hultman *et al.* 1984) and the new step feed process from Germany (Schlegel 1984) indicated the rising importance of nutrient removal. From the numerous papers on sludge treatment, the energy saving incineration concept of Stuttgart (Vater 1984) should be especially mentioned. Very interesting papers dealt with the new plants that were built for the chemical industry in Germany (Engelhardt *et al.* 1984).

For all four Workshops, the two founders W. Von der Emde served as chairman and John F. Andrews as vice chairman. They established a management committee consisting of renowned international experts like Eckenfelder (US), Kayser (G), Tench (UK) and later also Benedek from the Hungarian VITUKI Institute and Graefen from Germany. In 1983 it was decided to continue this activity with IAWQ LWWTP conferences rotating between Budapest, Prague and Vienna again every 4 years.

THE LWWTP WORKSHOPS AND CONFERENCES IN THE LIGHT OF THE CHANGES IN WASTEWATER TREATMENT PLANT DESIGN, OPERATION AND ECONOMICS UNTIL TODAY

Global changes and new requirements for treatment efficiency

When the first workshop took place in Vienna, the global population was ~3.8 billion people, and 50 years later it is 7.8 billion. This means that population has more than doubled during this period. For 1971, it can be assumed that about 5% of the global urban wastewater was subject to mechanical-biological treatment and estimated that this increased to more than 20% today. The result is that the capacity of urban wastewater treatment plants has grown by a factor of ~10, from serving maybe

200 million inhabitants to roughly 2000 million. During the same period, the mean treatment efficiency requirements have increased dramatically. In 1971, for most plants a BOD removal of ~90% was required; today, many of the large plants must achieve nitrification and nutrient removal. Nevertheless, already in 1971, plants with such advanced treatment efficiency were in operation for discharge to sensitive receiving waters; for example, discharge to lakes (like in Switzerland) or in South Africa to avoid eutrophication in the receiving waters with low dilution factors, and having in mind the reuse of the river water downstream. Even water reuse for drinking water supply in Windhoek was discussed at the Vienna Workshop in 1971, where physical-chemical treatment was applied. This concept was later abandoned and replaced by membrane bioreactors with adequate post treatment (Lahnsteiner & Lempert 2007).

Treatment technology development

Already in 1971, the most relevant treatment processes for urban wastewaters are still dominant today as they have proved to be reliable and efficient for water protection and even for reuse. The dominant biological treatment process is still the activated sludge process, which was further improved and developed with many new successful alternatives (Wanner 2021). Fixed film technologies like trickling filters and later biologically active filters (BAF) (Debarbadillo *et al.* 2010) have also reached a high technological standard and are still applied under specific local situations, but never became dominant, at least for large treatment plants.

Electronic data management, control, and automation

The rapid development of electronic data management and communication was already on the way in 1971, but the development has experienced an exponential growth until today. This development has dramatically influenced monitoring, control, automation, equipment and operation of WWTPs and it continues to strongly influence design, operation, and economics. Consequently, the professional training and education programs for the operating personnel need continuous adaptation, which was already a topic of the first workshop (Austin 1972).

As mentioned above, automation of treatment plants based on computer application was already a matter of intensive discussion at the first workshop. Participants of the Vienna Workshop (Guarino & Drake 1974) realised the relevance and initiated a new conference series on Instrumentation, Control and Automation, which finally resulted in the development of a very active and large IWA Specialist Group. For the last LWWTP conference planned for 2020 in Vienna, this topic was only dealt with in two papers on data mining for design and application of CFD (e.g. Patziger 2021).

Also, the IWA Specialist Group on Modelling and Integrated Assessment has taken care of this development and positively influenced the program of the LWWTP conferences. The application of mathematical models for design purposes, especially for extension of existing plants, has become a common important tool and was reflected in many LWWTP conferences.

Chemical and biochemical analytics

Another dramatic change in these 50 years is due to the development of chemical and biochemical analytics and instrumentation for wastewater. This development was and is driven by the great progress in chemical analysis, online monitoring instruments, ecology and ecotoxicity as well as of new legal requirements for water protection and water reuse. Meanwhile, the genetic analysis of wastewater and treatment plant biomes has also opened new windows for research and development in wastewater treatment (Lee *et al.* 2015; Nierychlo *et al.* 2015) even though a wide spread of these new tools is still of minor relevance for improved design and operation.

In 1971, the chemical analysis of wastewater was dominated by BOD as a pollution parameter, which resulted in the only internationally agreed pollution parameter of 60 g/PE/d for the population equivalent (PE), which is still used globally as a pollution currency despite its obvious weaknesses. This has dramatically changed during the last 50 years. It was driven by research and the development of the ASM 1 (Henze *et al.* 2000) as well the ADM 1 (Batstone & Keller 2003) and followers based on COD as a pollution and energy parameter allowing mass balances and dynamic modelling of the nutrient removal AS process and sludge anaerobic digestion, respectively. Common parameters for nitrogen and phosphorus compounds in wastewater have become the most relevant parameters for nutrient removal treatment plant design and operation. This has driven the development of online sensors for these parameters enhancing the application of automation strategies.

New topics have emerged during the last decade and are reflected in the program of the 2020 LWWTP conference. The emissions of the climate gas, nitrous oxide, from nitrogen removal plants as well as the removal of micro-pollutants, where chemical analysis can detect even concentrations in the range of μg/L and ng/L. These new developments clearly show that all the substances we use in our daily life or are present in our infrastructure can be detected in our wastewaters.

For many compounds, biological nutrient removal plants achieve high removal efficiency but even a great number of them are not affected and are of concern for ecotoxicology, especially in the case of bioaccumulation. Physical-chemical post-treatment processes are topics at the 2020 LWWTP conference (Teichgräber *et al.* 2021). While effluent disinfection (by chlorine) for pathogen removal was used in US in 1971, it has become more relevant also in Europe (mainly UV) and other continents for discharge to bathing waters and in the case of wastewater reuse for irrigation and even drinking water (Singapore). If micropollutant removal by physical-chemical post-treatment processes (ozone, UV treatment) are applied, disinfection can be a side effect. In Switzerland, an 80% removal of indicator compounds for micropollutants has become a legal requirement for all large treatment plants serving >80.000 inhabitants.

Sludge treatment and disposal

Already in 1971, sludge disposal belonged to the topics of great relevance and vivid discussion, and has remained a dominant area in all following conferences. For treatment plant managers, reliable sludge disposal at any time is vital as there is no way to treat wastewater without sludge production. Consequently, a new series of IWA conferences and a new specialist group on sludge management have been initiated.

The more recent development in sludge disposal has an important legal background. In 1971, sludge management was recognised as a wastewater-related problem, which had to be discussed with environmental agricultural, groundwater (landfill) and/or soil protection experts. Waste management legislation was still weak, and it was not expected that sludge disposal would become a matter of waste legislation. Even though water and waste legislation aims at the protection of human and environmental health, the stakeholders are different. Water legislation was recognised as a primarily public task without relevant commercial interest. Waste management legislation started later when private enterprises were already important stakeholders and included new developments in materials management with reuse and recycling requirements. At wastewater treatment plants today, there is a borderline between water legislation responsible for treatment efficiency and waste legislation taking care of sewage sludge management and disposal. Interestingly, the sludge treatment technology and the disposal routes are still a matter of sometimes even ideological discussion. In some countries and regions, mono-incineration before disposal has become a legal requirement at least for large plants (Switzerland and recently Germany); in others, incineration is politically banned due to bad experience in the past with exhaust gases (Italy). This discussion is actually animated by intensive research activity and also legal requirements for phosphorus recovery from wastewater (Germany). According to the German legislation, up to 2029 WWTPs larger than 100,000 PE and up to 2032 WWTPs larger than 50,000 PE have to abandon agricultural sludge utilisation and have to recover and recycle P from sewage sludge (AbfKlärV 2017). Sludge application in agriculture has remained a controversial topic and hence in the LWWTP conferences. In many countries it is allowed and even promoted (the US, Norway) as the best way for recycling nutrients and even organics to agriculture. In some countries with high cattle production, there is competition between manure and sewage sludge as fertiliser (Switzerland, the Netherlands). In the US, the main concern for sludge application on land is hygiene (Class A), in Europe it is heavy metals and actually micro-pollutants. In an increasing number of countries, agricultural application is banned or strongly restricted by strict quality parameters to avoid accumulation of hazardous compounds in soils or their transfer to crops (Switzerland and recently Germany). Especially during the first LWWP workshops, it became clear that at least for land application heavy metals must be controlled at their source, which resulted in remarkably successful legislation for the control of heavy metals at their source. Reports in the 1970s on this topic revealed, for example, Cd and Hg concentrations in the range of 60–80 mg/kg DS (Chicago, Vienna). Today the concentrations have dropped to even below 2 mg/kg DS.

Sludge treatment technology is strongly influenced by the selected disposal route, depending on site-specific legal and other local aspects. It is also relevant regarding energy management as sludge has an important energy content. This energy can be recovered either by conversion to biogas or as an energy source for incineration. During the 50-year period, anaerobic digestion of thickened sludge, mostly mesophilic but also thermophilic, has remained common technology without major process innovations. The main problems discussed have been digester construction (cylindrical versus egg shaped), scum control and mixing. One important progress reported at the conferences was the gas-motor development resulting in increased efficiency of the conversion of biogas to electric power from ≤25% in the 1970s to about 40% today (Kroiss 2019; Tauber *et al.* 2019). The aim of achieving energy self-sufficient treatment plant operation without external substrate addition has become realistic. Nevertheless, a lot of other improvements have resulted in reduced energy consumption, not only by more efficient aeration systems.

Also, papers on sludge dewatering over this period show positive developments. A first important new requirement derived from sanitary landfill disposal in order to avoid landslides. This favoured the use of filter presses with lime conditioning. For agricultural use, again high solids concentrations reduce problems with liquefaction during transport. Also, for sludge drying and incineration the water contents of the dewatered sludge is dominant for the evaporation energy requirement. New dewatering technology appeared during the last decades: screw presses and the Bucher press coming from the food industry. The progress in final moisture content is slow and is dependent on so many site-specific conditions that comparison is difficult. Overall, cost minimisation is the most relevant driving force.

Thermal hydrolysis before digestion was mainly a matter of research and despite failures in the past was developed to a well-established sludge pre-treatment process to enhance anaerobic digestion and reduce solids disposal (Siegrist *et al.* 2015). This pre-treatment results in higher organics conversion to biogas and improved dewaterability of the digested material. Due to markedly lower viscosity of the pre-treated sludge, digesters can be operated at high solids concentrations in the feed sludge, even >8% DS, hence lower reactor volume requirement. The increased ammonia load in the centrate strongly favours the application of the deammonification processes for nitrogen removal and struvite precipitation for phosphorous removal. Economic advantages of this process depend on many site-specific conditions. Due to the complex chemical engineering process needing especially skilled operators this process is probably suited for large plants only.

Relationship wastewater treatment and sewer system

Wastewater flow control in the sewer system to improve treatment plant automation was reported at the first Vienna Workshop (Anderson 1972). The topic reappeared at the 2011 conference, mainly regarding nutrient removal optimisation (de Korte *et al.* 2009; Hartwig 2012). Interestingly, the close relationship between sewer system and treatment plant did not show up in the LWWTP topics. It should become more relevant in the future as influent composition and concentrations are strongly dependent on site-specific catchment characteristics. The influent concentrations reported in literature vary between <300 mg COD/L and >1,000 mg/L. They reflect the behaviour of the cities' population, industry and trade in water consumption and pollution transfer, but also the repair and maintenance status of the sewers. Influent concentration can play a dominant role in water protection in the case of sewer exfiltration and for dilution of the wastewater by infiltration. The lower the influent concentration, the higher the effluent pollution load of all biodegradable compounds, if the effluent concentration is the same. Also, the comparability of operational data from different treatment plants having different influent concentrations is crucial; for example, the comparison of operational cost for WWT related to 1 m^3 of wastewater tends to be misleading (Brisco 1996), while costs related to pollution load are only little sensitive to influent concentrations for conventional AS process. This was demonstrated by Lindtner *et al.* (2008) for a regional benchmarking analysis. For plants with membrane bioreactors (MBR) the hydraulic load becomes an important operational cost factor, which makes cost comparison between conventional and MBR treatment systems difficult.

Design and upgrading of treatment plants

Design guidelines are necessary to make the basic design of plants. During the 50-year period, design guidelines have been improved and adapted to the new treatment efficiency criteria; for example, the famous DWA Guideline A-131 which in 1971 was based on BOD loading rate and BOD and SS effluent standards, while the actual version (2016) is based on sludge age, COD and N mass balance concept and nutrient removal requirements.

The design guidelines are complemented by a great number of dynamic mathematical models such as ASM, ADM and others, which are able to integrate the whole scientific knowledge and experience regarding the hydraulic, biochemical and chemical processes involved, which is beyond the simultaneous capacity of the brain for process simulation. These new tools are important for solving a great variety of problems for design and operation.

Many papers were present at the conference series regarding the design of new plants as well as enlargement and upgrading of existing plants. Some important ones are mentioned here: Prague (Kos *et al.* 2015), Stuttgart, Zürich-Werdhölzli plant (Siegrist *et al.* 2000), Hamburg extension by two-stage AS plant, which was further developed for Vienna, Washington Blue Planes (Matthew *et al.* 2011), Wuppertal (Eisert & Erbe 2015), Stockholm (Andersson *et al.* 2016), Tel Aviv (Messing & Sela 2016), and Vienna (Kroiss & Klager 2018). Design concepts for large new plants like Mexico City Antonilco plant (de la Espino *et al.* 2011), Singapore Changi plant (Daigger *et al.* 2008) and many others were reported during the 50-year period.

NUTRIENT REMOVAL AND LARGE WASTEWATER TREATMENT PLANT CONFERENCE 2017 IN CHONGQING AND LWWTP CONFERENCE PLANNED FOR VIENNA 2020

During the LWWTP 2015 conference in Prague, it was agreed in the specialist group meeting that it would be important to extend the conference into other continents where the number of large WWTPs is massively increasing. To achieve this, the idea of in-between conferences was born. The aim was to keep the four-year rotation between Vienna, Prague and Budapest and to include every second year a conference in a different region of the world. Due to the commitment of the management team of the Specialist Group, the first in-between conference took place from 7th till 9th November 2017 in Chongqing, China. This conference was organised together with the Specialist Group for Nutrient Removal and Recovery and excellently organised by Prof. Dr Qiang He and the team of the Chongqing University. Under the title 'Sustainable Wastewater Treatment and Resource Recovery: Research, Planning, Design and Operation' a wide range of research and scientific themes as well as planning, design and operational themes were covered. In the scientific field, short-cut nitrogen removal in side- as well as main-stream were still important topics (Xu *et al.* 2017), as was the minimisation of nitrous oxide emissions during the treatment process (e. g. Zaborowska *et al.* 2017). On the planning side of things, several presentations ranged around the implementation of aerobic granular sludge (Corsino *et al.* 2017; Giesen *et al.* 2017), modelling (e.g. Du & Dold 2017) as well as biofilm systems (e.g. Rathnaweera *et al.* 2017).

The 13th Specialised Conference on Design, Operation and Economics of Large Wastewater Treatment Plants was planned from 10th till 14th May, 2020 in Vienna. Based on the normal schedule the conference should have been scheduled in 2019, but to appropriately celebrate the 50th anniversary of the starting of the Workshop idea, which was in 2020, it was decided to move the conference date into 2020. The conference was fully planned, and all presenters had submitted their abstracts, when the Corona outbreak made travelling and attending international conferences in many regions of the world impossible. Initially the event was postponed to June 2021, but when it became clear that the Corona pandemic would last longer and considering the large number of conferences that had been postponed, it was decided to completely cancel the LWWTP2020/2021 conference in Vienna.

The next LWWTP conference is planned to take place in Budapest in 2024.

DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

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