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10th International Conference on Swimming Pool & Spa

Sustainability of Swimming Pools and Spa in a One Health Perspective

Organized by
the Italian National Institute of Health
and University of Rome "Foro Italico"
Bologna, February 15-17, 2023

Edited by
E. Ferretti, L. Lucentini, F. Nigro Di Gregorio,
V.R. Spica and F. Valeriani

ISTITUTO SUPERIORE DI SANITÀ

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ABSTRACT BOOK

Edited by
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This volume gathers the abstracts of the contributions presented at the 10th International Conference of Swimming Pools & Spas, the biennial international conference on the safety and quality of bathing and thermal waters for swimming pools and spas. "Sustainability of Swimming Pools and Spas in a One Health Perspective" was the theme of the event, under the scientific direction of the Italian National Institute of Health (ISS) and Rome's "Foro Italico" University. An audience of authoritative names from the international academic world - from Europe, USA, Canada, Australia and the Middle East - and from some of the most prestigious Health Institutes gathered for the 10th ICSPS in Bologna (Italy). The main aims were to discuss public health in the attempt to develop a safe, sustainable approach to spread a health-promoting culture through recreational waters, in the light of the many scientific and technological advancements of the last few years.

Key words: swimming pool, water and health, spa

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Questo volume raccoglie gli abstract dei contributi presentati al 10º Convegno Internazionale di Piscine & Spa, il convegno internazionale sulla sicurezza e la qualità delle acque balneabili e termali per piscine e spa. "Sostenibilità di Piscine e Terme in una prospettiva One Health" è stato il tema dell'evento, sotto la direzione scientifica dell'Istituto Superiore di Sanità (ISS) e dell'Università "Foro Italico" di Roma. Un pubblico di nomi autorevoli provenienti dal mondo accademico internazionale - dall'Europa, dagli Stati Uniti, dal Canada, dall'Australia e dal Medio Oriente - e da alcuni dei più prestigiosi Istituti di Salute si sono riuniti per il 10º ICSPS a Bologna (Italia). Gli obiettivi principali sono stati quelli di discutere la salute pubblica nel tentativo di sviluppare un approccio sicuro e sostenibile per diffondere una cultura di promozione della salute attraverso le acque ricreative, alla luce dei numerosi progressi scientifici e tecnologici degli ultimi anni.

Parole chiave: piscine, acqua e salute, spa

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CHEMISTRY OF CHLORINE IN POOLS AND MICROBIAL SENSITIVITY

L. Erdinger
Center for Infectious Diseases, Department for Medical Microbiology and Hygiene, University Hospital Heidelberg, Heidelberg, Germany

Soon after the existence of bacteria and other microorganisms had been discovered, the disinfecting properties of "bleach" were investigated. Drinking water disinfection was introduced as early as 1907 in the US, the disinfection of swimming pool water started a couple of years later. Chlorine is a highly reactive chemical element which may not only oxidize compounds but may also form other disinfection by-products by various reaction mechanisms. "Breakpoint chlorination" is a phenomenon known since long describing the fact that the concentration of free chlorine will only reach concentrations necessary for disinfection as soon as contaminants in the water have been reacted with chlorine. Nitrogen containing organic and inorganic molecules will react to form so-called "combined chlorine". However, the composition or identity of combined chlorine as well as its fate is poorly understood. It may be presumed, that nitrate may be a final reaction product for nitrogen containing compounds. Both the disinfection as well as the bleaching activity of chlorine are based on the oxidation properties of hypochlorous acid formed together with hydrochloric acid by disproportionation of elemental chlorine in water. Because hypochlorous acid contains chlorine in the oxidation state +1 it is a strong oxidant. The "normal potential" and oxidizing power of the HOCl/HCl System (1495 mV at pH=0) is mainly influenced by the pH and may be calculated using the Nernst equation. At low pH, chlorine is mainly present as hypochlorous acid and the oxidation capacity is significantly boosted compared to its activity at increasing pH, where the hypochlorite anion is prevalent. The capability for disinfection of chlorine is directly connected to the oxidation potential and therefore, disinfection works better at low pH. Hence, the "CT-rule" is a function of the pH of the water. CT stands for concentration (C) times contact time (T) and is the concentration of the disinfectant multiplied by the time that the disinfectant is in contact with the water. Just like chemical compounds are not equally sensitive to oxidation, there are differences in the "oxidation tolerance" of microbes. Whilst gram-positive organisms like *E. coli* or *P. aeruginosa* show high sensitivity to chlorine, especially if they are present in "planctonic state", gram-negative organisms tolerate higher concentrations of the disinfectant and may survive for prolonged time-spans. Disinfection kinetics is easy to describe if gram-negative organisms are in focus, and if the pH is low. In this case, the decay rate is linear and very fast. In case of gram-positive microbes the kinetic models are more complicated and predict the survival of individual cells. Sensitivity to chlorine varies within certain species and is probably log-normal distributed. This is a big difference compared to chemical compounds, where the sensitivity to a certain oxidant is constant and where the rate of certain oxidation reactions may be described more or less simply. In the water of swimming pools, the efficiency of disinfection is linked to the presence of other oxidizable compounds making

effective water purification an imperative necessity for the success of disinfection. Microbiological analysis of the water may be helpful as a process indicator for water disinfection. However, although the analysis of *E. coli* is included in many rules world-wide, it may be questioned if this is really meaningful regarding the sensitivity of gram-negative bacteria in general. The use of a gram-positive organism as an indicator would probably be more helpful for the microbiological assessment of the disinfection process.

Session I

Current Regulations from different countries

Chairpersons
Michele Hlavsa, Emanuele Ferretti

SURVEILLANCE AND PUBLIC HEALTH POLICY IN USA

M.C. Hlavsa (1), S.K. Aluko (1,2), V.A. Roberts (1), J.P. Laco (3), M.J. Beach (1), V.R. Hill (1)
(1) CDC, Centers for Disease Control and Prevention, Division of Foodborne, Waterborne, and Environmental Diseases, Atlanta, GA, USA
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In the United States, local (city or county), state, or territorial jurisdictions individually determine which illnesses and injuries (including drowning) must be reported to public health agencies. U.S. jurisdictions vary in their capacity to detect and investigate outbreaks and cases and then report them to U.S. national surveillance systems. Additionally, public pools, hot tubs/spas, and splash pads are regulated to varying degrees (i.e., in some jurisdictions not at all). This patchwork approach is a barrier to healthy and safe swimming. Over the last 20–30 years, CDC has led efforts to detect, investigate, report, and prevent recreational water–associated illness and injury across U.S. jurisdictions-i.e., launch and hone national surveillance systems to collect standardized data, use those data to characterize recreational water–associated illness and injury epidemiology, and develop evidence-based prevention policy. For example, CDC's Waterborne Disease and Outbreak Surveillance System has evolved from being paper-based to electronic and in multiple electronic iterations (e.g., substantially reducing the number of data fields to increase reporting timeliness and data completeness). Additionally, since 2014, CDC's Model Aquatic Health Code (MAHC) has provided evidence-based design, construction, operation, and management recommendations that U.S. jurisdictions and the aquatics sector can voluntarily adopt to help prevent illness and injury at public pools, hot tubs/spas, and splash pads. For 2015-2019, public health officials in 36 states and the District of Columbia reported 208 treated recreational water–associated outbreaks to CDC. These outbreaks resulted in at least 3,646 cases of illness. *Cryptosporidium* caused 76 (37%) outbreaks, resulting in 2,492 (68%) cases. During 2018–2021, investigations of primary amebic meningoencephalitis cases have, for the first time, implicated single-pass and recirculating splash pads and novel surf venues as sources of fatal *Naegleria fowleri* infections. In 2022, CDC finalized the 4th edition of the MAHC. Updates include locating splash pad UV systems after feature pumps to inactivate *Cryptosporidium* in 100% of the water before it reaches users. The 5th edition of the MAHC will need to address the design, construction, operation, and management of novel surf venues and single-pass splash pads, which are not addressed in the 4th edition MAHC.

IMPLEMENTATION OF THE NEW FRENCH REGULATIONS ON SWIMMING POOLS

J.-L. Boudenne, B. Coulomb
Aix Marseille University, CNRS, LCE, Marseille, France

The previous regulations applicable to swimming pools dated mostly from 1981, before being updated in 2020 for an implementation in January 2022. The new decrees amend the provisions on the safety of swimming pool water open to the public, taking into account, in particular, the evolution and diversification of recreational practices, the progress made in water treatment and the design of pools. These amendments concern in particular the scope of the installations concerned, their monitoring and analysis methods, as well as water cycle times according to the category of basins and the management of situations of non-compliance with the regulations. These new regulatory provisions apply to all public and private swimming pools for collective use since 1 January 2022. Swimming pools in health facilities, medico-social institutions and physiotherapy practices fall within the scope of application. Certain types of swimming pools have been excluded from the scope because they are considered to be non-collective use. These pools are more for single-family use: private swimming pools reserved for the personal use of the owner or tenant of the dwelling, private pools reserved for the personal use of transient customers who rent the dwelling and who do not take up residence there, and finally private pools reserved for the personal use of the client of a unit, whether a room, a site or apartment of the commercial tourist accommodation and which does not take up residence there. Besides classification by type of pools, the main changes in the new regulation concern water quality standards for swimming pools and the quality control of swimming pools' water. In the context of sanitary control, the methods of monitoring water quality are defined according to the types of basins. In addition, new parameters have been introduced. With regard to water quality standards, new water quality limits and references for swimming pools have been set.

REQUIREMENTS ON THE DISINFECTION CAPACITY OF POOL WATER ACCORDING TO THE AUSTRIAN BATHING HYGIENE REGULATION

R. Sommer, M. Reiter, E. Holzhammer
Medical University Vienna, CePII, Institute for Hygiene and Applied Immunology, Water Hygiene, Vienna, Austria

Austria has a long tradition in legislation on the quality of bathing water to protect the health of the bathers. The requirements are laid down in a national law on Bathing Hygiene as well as a Regulation of the Minister of Health on bathing hygiene in pools, whirl tubs, sauna facilities, hot air and steam baths and natural ponds. This Regulation is actually under revision and is expected to come into force in 2023. The regulation on water for pools intended to be used by several bathers simultaneously demands continuous water treatment by flocculation and filtration as well as disinfection by chlorination. Disinfection with chlorine after water purification can be considered the most effective infection control measure in the field of bathing pool hygiene. Beside the operation parameters for the application of chlorination the disinfection capacity is defined by the following requirement: Under the conditions given *Pseudomonas aeruginosa* has to be inactivated in the pool water within 30 seconds for 4-log (factor 10.000). Our study was performed in different types of therapy pools of hospitals. The aim of our study was to investigate the factors chlorine concentration and pH-value on the disinfection capacity during regular bathing operation and conditions. Moreover the concentration of Trihalomethans (THM) as most prominent chlorine Disinfection by-Products (DPD) was monitored. To investigate the disinfection capacity a pool water sample (500 ml) was inoculated on-site immediately after taking with a suspension of *P. aeruginosa* resulting in a final concentration of $1{,}0.10^6$ per 100 ml. After a reaction time of 30 seconds sodium thiosulphate solution was added to stop the inactivation effect of the chlorine. As reference the same experiment was performed in pool water sample in which sodium thiosulphate was added in advance to neutralize the effect of chlorine. The reduction of *Pseudomonas aeruginosa* was calculated by the difference of the log concentration in the pool water sample after chlorine inactivation and the log concentration in the reference sample. All experiments were carried out twice and the samples were processed in triplicate. In addition chemical analyses were performed to characterize the water of the different pools. The results revealed that the disinfection capacity of at least 4 log reduction of *P. aeruginosa* within 30 seconds was achieved, but only under the condition that, in addition to the chlorine concentration, the pH value is also within the intended range.

CURRENT REGULATIONS FROM GREECE

A. Vantarakis
Department of Public Health, Medical School, University of Patras, Patras, Greece

The conservation of swimmers' health is of prime importance while using swimming pools. The absence of antiseptic chemical compounds in the water, in the appropriate quantity, could lead to infectious diseases. There are plenty of infectious diseases that can be transmitted by recreational water. These diseases include skin, ear, and eye infections, and gastroenteritis. There are many microbiological pathogens that could cause waterborne diseases such as parasites, bacteria, and viruses. Pseudomonas aeruginosa infects swimmers' ears (pools) and Staphylococcus aureus infects the skin, wounds, and ears and the sources are from bathers shedding in pool water. Waterborne diseases have momentous repercussions both locally and globally. As a result, it is necessary to reduce the levels of microorganisms in recreational waters to combat the health hazards related to swimming. The last 10 years the Greek regulations have been modified several times to protect the public. The latest Greek regulations are presented according the different types of swimming pools, which include several sections such as the source of water, water disinfection, water circulation, protection of water quality, microbiological and chemical limits, liquid waste, risk assessment, personnel working.

GUIDELINES ON THE QUALITY OF SWIMMING POOL WATER IN POLAND

J. Wyczarska-Kokot, A. Lempart-Rapacewicz, E. Kudlek, M. Dudziak
Silesian University of Technology, Faculty of Energy and Environmental Engineering, Department of Water and Wastewater Engineering, Gliwice, Poland

In most European countries, there are state regulations that govern the mandatory sanitary requirements of public swimming pools, especially the physiochemical and bacteriological parameters of water quality. In Poland, after many years of discussion and adaptation of legal documents on bathing water quality to the standards of the European Union law and the World Health Organization guidelines, the Regulation of the Minister of Health on the requirements to be met by water in swimming pools was published on 9 November 2015 (Journal of Laws 2015, item 2016). The regulation also specifies the frequency of water sampling, the reference methods of analysis, and the method of assessing water quality in the pool circuit. In addition to the Regulation of the Minister of Health on the requirements to be met by water at swimming pools in Poland, the following are also taken into account:

- Guidelines on water quality and sanitary and hygienic conditions in swimming pools, issued by the Chief Sanitary Inspectorate, Department of Water Health Safety in 2014;
- Recommendations of the National Institute of Public Health - National Institute of Hygiene on sanitary and hygienic requirements for swimming pool facilities and water quality in swimming pools intended for infants and children aged 6 months to 3 years, issued in 2012;
- The recommendations of the German DIN 19643 (Treatment of swimming and bathing pool water), issued in 1997 and updated in 2012, pretending to be a unified standard;
- Sanitary and hygienic requirements for indoor swimming pools issued by the Department of Public Health, (Warsaw 1998), based on DIN 19643 of 1997 by Sokołowski;
- The World Health Organisation, WHO (Guidelines for Safe Recreational Waters. Volume 2. Swimming Pools and Similar Recreational-Water Environments) from 2006.

The provisions of the Regulation of the Minister of Health apply to swimming pools in which the swimming pool basins with an internal pool water circulation and treatment system are filled with waters meeting the requirements for drinking water, saline waters containing between 5 g/L to 15 g/L of mineral elements, as well as thermal waters (excluding waters originating from the dewatering of mine workings). With regard to the quality of water for swimming, bathing, sport and recreation in swimming pools, the requirements apply to water entering the pool basin from the circulation system and to water in the various types of pool (sports, recreational, equipped with water aerosol generating devices, made available for swimming lessons for infants and young children under 3 years old). The evaluation of swimming pool water quality carried out by the swimming pool manager consists of a visual assessment of the water quality in the individual swimming pool basins, control of the operation of the equipment of the swimming pool recirculating water treatment station by measuring water quality parameters, i.e. pH, oxidation-reduction potential (redox),

temperature, and free and combined chlorine content. In view of the variety of solutions for swimming pool water treatment systems offered by specialised companies, standardisation of hygiene, design, and functional requirements for swimming pool facilities and their evaluation and adaptation to modern technical and technological developments are becoming a necessity. In Poland, at numerous symposia and conferences, the above-mentioned pool water quality recommendations are discussed by scientists, pool water technology experts, producers of pool water treatment equipment and pool facilities managers.

CURRENT REGULATIONS IN THE NETHERLANDS

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Dutch pools are regulated since 1984 and regular updates to this legislation have been done during the years. Health and safety of swimmers are the key elements in this legislation. Besides pool water quality also other aspects are mandatory, like recirculation rates, overflow %, depth indicators, safety lines, roughness of pool surrounds, pool floor slope, used materials and many more. The pool manager must carry out regular health and safety checks to ensure healthy and safe pools. These are checked by health officials on a yearly base. The health authority has the power to close a swimming pool if regulations are not met. Current limit values in Dutch pools are: Colonies 37°C (≤100cfu/mL), Pseudomonas aeruginosa (≤1 cfu/100 mL), water transparency (visual clear sight / bottom), Turbidity at pool outlet (≤ 0.50 NTU), KMnO4 consumption (mg/L / function of tapwater), Acidity (6.8≤pH≤7.8), Alkalinity (≥1 mmol/L), Urea (≤2.0 mg/L), Free chlorine (0.5-1.5 mg/L), Combined chlorine (≤1.0 mg/L), Cyanuric acid (≤50 mg/L), Ozon (n.d. mg/L), Legionella (<100 cfu/L). Some parameters are not mandatory, but the health authority can make them mandatory on demand. Faults are calculated on a yearly base, depending on the number of months opened to the public, a pool can have max 3 faults per year. New legislation for Dutch pools is published and ready to go operational in June 2023. In this new legislation all means rules are dropped. Pools can be operated as long as target rules are gained. Target rules are pool water and air parameters. Additionally, a health and safety analysis is mandatory. All health and safety risks need to be analysed and for unacceptable risks, management measures are mandatory. Pool operators can make their own risk assessment. Water quality parameters from June 2023 will be: Free chlorine (0.5-1.5 mg/L), outdoor pools (0.5-5.0 mg/L), Combined chlorine (≤0.6 mg/L), Acidity (6.8≤pH≤7.8), Water transparency (visual clear sight/bottom), Turbidity at pool outlet (≤0.50 NTU), Bromate (≤100 µg/L), Chlorate (≤30 mg/L), Chloride (≤1000 mg/L), KMnO4 consumption (≤3.5 mg O2/L), Nitrate (≤70 mg/L), THMs (≤50 µg/L), Urea (≤2.0 mg/L), Alkalinity (≥40 mg/L HCO3), Intestinal enterococci (≤1 cfu/100 mL), Legionella (≤100 cfu/L), Pseudomonas aeruginosa (≤1 cfu/100 mL), Spores of sulphite reducing Clostridia (≤1 cfu/100 mL). Air quality parameters from June 2023 will be Ozone (≤ 120 µg/m³) and Trichloramine (≤500 µg/m³).

THE ITALIAN SWIMMING POOL REGULATORY FRAMEWORK

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Aims. On December 2020, an Interregional Working Group, together with the Italian Ministry of Health and the Italian National Institute of Health, was set up to define the discipline of the swimming pool sector and regulate those aspects not yet considered in the Italian 2003 Agreement on this sector.

Regulatory framework and updating activities. The document produced represents an overall framework of the swimming pool sector, which contemplates the essential health and hygiene requirements, includes updates, and harmonises the discipline on a national level while fully respecting the subsequent competences on a regional scale. The proposal potentially lends itself to being channeled into a Ministerial or Interministerial Decree.At the same time, the Italian standard UNI 10637:2015 (mentioned in the new document) is being revised and optimized by the UNI WG11 involving several authoritative Italian experts (*e.g.,* Assopiscine, Italian National Institute of Health, etc.).

Results and conclusions. The main topics updated in respect of the 2003 Agreement:

- Regulation of swimming pools supplied with seawater.
- Regulation of natural pools such as e.g., bio-lakes and bio-pools.
- Inclusion of new tables of parameters for the quality of the supply water, of the pool, of the microclimate and of the substances for the treatment of the pool water.
- Freshwater supply: water from wells or springs with derogations from the requirements of decree for drinking water, transposition of the Directive (UE) 2020/2184, (suitable for recreational use but not necessarily drinking); alternatively supply with water declared in good chemical status in relation to Directive 2000/60/EC criteria.
- Classification of swimming pools in condominiums and residences that, for their collective use and the associated risks, are considered private pools for collective use.
- The definition of private "domestic" swimming pools shall be limited to the exclusive use of family members and their guests. When they are rented out to third parties, they become pools subject to a minimum of regulation regarding risk prevention, in particular to ensure water quality, the essential elements for the safety of bathers and traceability.
- The identification of the figure of the Pool Manager, Responsible for the safety of bathers and the Manager of technological/maintenance systems, as subjects that contribute to the safe management of the pool (in analogy with the 2003 Agreement).
- The implementation of the principles of auto-control in order to reduce also risks connected with the internal distribution systems, according to the article 10 of the Directive (UE) 2020/2184 on priority premises. The proposed document is currently under final review and consultation between the institutional bodies.

Session II

Chemical Risk

Chairpersons

Jean-Luc Boudenne, Marteen Keuten

DISCRIMINATION OF DISINFECTION BY-PRODUCTS GENERATED BY PARTICLES FROM THOSE FORMED BY DISSOLVED COMPOUNDS BROUGHT BY BATHERS

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Disinfection of swimming pool water -often performed with chlorination- is a crucial step to prevent waterborne infections. An unintended consequence of treating water with chemical disinfectants is the formation of disinfection by-products (DPBs) associated with adverse health effects due to reactions between the added disinfectant and organic matter present in water. To date, most of studies interest in the reactivity of chlorine with dissolved organic compounds brought by bathers (sweat, urea or whether personal care products). This study focuses on the reactivity of chlorine with particles brought by bathers (such as skin cells or hair) by interesting in the consumption of chlorine and identification and quantification of DBPs generated during chlorination of such particles. Particles were collected in two swimming pools during five sampling campaigns, at the outlets of filter backwash wastewater. They were then characterized by granulometry (distribution of particle size), microscopic observations, and in terms of carbon and nitrogen content. These particles were then chlorinated as such (79 mg L^{-1}) and as diluted suspensions (36.2 and 11.9 mg L^{-1}) at different doses of chlorine (1.2 mg and 24 mg Cl_2 L^{-1}). Kinetics of chlorine consumption and of DPBs formation (analysis of trihalomethanes (THMs), haloacetic acids (HAAs), haloacetonitriles (HANs), chloral hydrate and trichloropropanone) have been followed by spectrophotometry and gas chromatography coupled to an electron capture detector (GC-ECD), respectively. Whereas chloroform was the major DBP formed during experiments carried out at low dose of chlorine (up to 25.7 µg L^{-1} within 96 hours at 1.2 mg Cl_2 L^{-1}) followed by Haloacetic Acids (HAAs) and haloacetonitriles (HANs), increasing dose of chlorine shifted the predominance of DBPs to HAAs, with formation of trichloroacetic acid up to 231.8 µg L^{-1} within 96 hours. Finally, by linking organic content of particles with nature of DBPs formed, formations of 0.13 µmol THMs, 0.31 µmol HAAs and 0.04 µmol HANs per mg of Dissolved Organic Carbon (DOC) was established.

IDENTIFICATION OF DBPS FROM DIFFERENT DISINFECTANTS

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Ultraviolet (UV) light, coming from the sun, causes damage to materials, which are exposed to it. Photons of UV light cause breakage of covalent bonds and thus induce different oxidation processes, which are mainly chain-radical oxidation reactions with air oxygen. These processes lead to aging and weathering of different construction materials, coatings, plastics, and rubber. Particularly harmful, however, are these processes in biological systems, where they cause damage to skin cells, resulting in accelerated aging of the skin and the emergence of various diseases, from inflammatory processes to cancer. To protect against UV light, various substances, named UV filters, are used that either reflect or absorb UV light. Increasingly, however, they are also used in personal care products (e.g. sunscreen, lipsticks, shampoos and hair sprays) as a result of the growing awareness of the harmful exposure to the sun and the consequent increased risk of morbidity for skin cancer. Besides UV filters, sunscreens may contain other compounds such as antioxidants, which are also thought to play role in protecting the skin from the effects of exposure to UV light. Sunscreen products are used primarily in settings, such as swimming pools and sea, in the snow and in the mountains, where thorough protection is needed. However, several studies showed that UV filters may degrade or react by light. This occurs mostly through two types of reactions: (a) direct photolytic reactions, and (b) chlorination of aromatic rings or side chains, which is due to the presence of chlorine and a chlorate medium (such as those found in pools, or salty seawater).In our study we focused on transformation of selected UVA (avobenzone) and UVB (BP3, DHHB) filters as well as some antioxidants (resveratrol, limonene) in sunscreens under disinfection conditions. The formation of halogenated byproducts in chlorinated waters is inevitable, especially when compound possess double bonds, phenolic, keto-, or amino moieties. Various experimental conditions (media, light of specific wavelengths, addition of ions, disinfectants, and their combinations) influence the formation of different products, which were identified by HPLC-MS/MS, independent synthesis, NMR spectroscopy and GC/MS. It should be worth mentioning among the most relevant from the environmental point of view one should mention chloroanhydrides and chlorophenols (chlorination experiment) as well as brominated phenols and substituted acetophenones (bromination experiment) in the case of avobenzone. Comparative toxicity assessment of parent UV filters and primary mono and dichloro substituted products on non-target organisms daphnids, microalgae and photobacteria as well as on model human lung epithelial cell line A549 have been performed. The results have shown differences between the type of tested UV filter, modified effects after chlorination, and species-specific effects.

IDENTIFICATION OF MICROPOLLUTANT DECOMPOSITION PRODUCTS IN PRIVATE BACKYARD SWIMMING POOLS

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The water quality in private backyard pools water does not always meet the standards for swimming pool water. This is due to the lack of the need to meet such high standards. However, this fact raises concerns among many users. Earlier analyzes of water from backyard swimming pools showed the presence of a wide range of micropollutants belonging mainly to the group of pharmaceuticals and personal care products, plasticizers, preservatives, refractories and other industrial additives. These compounds get into the water from the body surfaces and secretions of the users and are washed out from all objects, which come in contact with the pool water. Those compounds undergoing numerous changes, which direction depends strictly on the used methods of water treatment. The private pool water treatment and disinfection systems are basing mainly on filtration processes supported periodically by the action of coagulants, algaeicides, pH stabilizers and chlorine-based disinfectants. The aim of the presented research was to trace the changes that selected organic micropollutants undergo during contact with algaeicides, coagulants, pH stabilizers and chlorine-based in pool water exposed to direct sunlight. The chromatographic analysis of water samples subjected to the action of different pool water treatment agents indicated the formation of compounds, which previously did not occur in this specific water environment. Those newly formed compounds were not retained in the filtration process on cartridge and/or sand filters and can have an adverse effect on the quality of pool water.

CHLORINATION BY-PRODUCTS IN INDOOR SWIMMING POOLS: YEAR-WISE MONITORING STUDY

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Chlorination is the most common method for disinfection of pool water in Turkey. Despite the chlorination of swimming pools ensuring microbial safety to prevent water-borne diseases, a reaction between organic compounds, dissolved ions, and chlorine forms the toxic disinfection by-products (DBPs). Indoor swimming pools are abundant environments due to continuous disinfection and input of precursors from swimmers. Trihalomethanes (THM) and haloacetic acids (HAA) are the most abundant DBPs in swimming pools. In this study relation between pool water quality parameters and DBPs concentrations were investigated with a year-wise monitoring campaign in two indoor swimming pools (SP-A and SP-B). Before the monitoring campaign, both pools were cleaned and refilled with individual operating procedures. While SP-A was refilled with a chlorinated drinking water distribution system, SP-B was refilled directly with groundwater. THM, HAA, and Haloacetonitriles (HAN) were the targeted DBPs. Free chlorine, UV254 absorbance, Dissolved Organic Nitrogen (DON), Total Organic Carbon (TOC), and Adsorbable Organic Halides (AOX) concentrations were weekly analyzed during year wise monitoring campaign. While the average pool water THM and HAA levels were determined to be 20.6 µg/L and 55 µg/L in SP-A, respectively, those were 69.6 µg/L and 385 µg/L in SP-B. HAN were relatively lower than the THM and HAA in both SP-A and SP-B might be due to the rapid degradation and low formation at pH>7. While the maximum HAN concentration was determined to be 2 µg/L, the average level was 2.90 µg/L in SP-B. Simple linear regression (SLR) analysis shows the co-occurrence of THM, HAA, and HAN were significant (r^2=0.63-0.77, $p<0.01$). THM, HAA, and HAN concentrations were determined to be strongly related to DOC, DON, and AOX levels. Also, $SUVA_{254}$ was related to THM and HAA concentrations, while not related to HAN. SLR models might be used to estimate DBP levels in sample pools without the need for a complicated sample preparation process, chromatography analysis, and expensive analytical instruments.

COMPARISON OF CHLORATE AND PERCHLORATE CONCENTRATIONS IN SWIMMING POOL WATER AND THEIR CORRELATION WITH THE USE OF CHLORINE PRODUCTS, PROVIDED IN READY-MADE CANISTERS OR GENERATED *IN SITU* BY SALT ELECTROLYSIS

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The German din 19643 'treatment of swimming pool and bathing water' establishes a major value of "chlorite + chlorate" of 30 mg/l in swimming pools. Also, the new european standard en 17818 about *in situ* generated chlorine products requires the measurement of the parameter chlorate (and other toxicologically relevant parameters). Chlorite and chlorate are in discussion because of their toxicological effects. They form more or less in all types of swimming pools (and in other applications) with chlorine disinfection but are more prominent where ready-made sodium hypochlorite solution is applied as a disinfecting agent. All examined swimming pools disinfected with chlorine gas from pressurized bottles have chlorite + chlorate concentrations far below 30 mg/l but pose a potential hazard to both occupational and bathers and sometimes the surroundings safety. On the contrary, disinfectants and disinfection methods which provide high occupational and bathers safety are chlorine products, which are generated *in situ* by salt electrolysis. Recent studies suggest though that also these methods seem to be prone to higher concentrations of chlorate (and perchlorate). But also, very low chlorate (and perchlorate) concentrations have been associated with *in situ* generated chlorine. The chlorate concentration found in swimming pools disinfected with chlorine, generated *in situ* by electrolysis of sodium chloride therefore seems to depend on the mode of action, the mode of operation or both and/or other factors. The author has thus performed a comparison of various *in situ* electrolysis systems available on the market and compared the chlorate concentrations in the swimming pools disinfected by ready-made sodium hypochlorite solution, *in situ* generated sodium hypochlorite solution and *in situ* generated chlorine gas. To this end, data from over 10 years of observation has been collected from laboratory reports and relevant studies and literature were evaluated, comparing the chlorate concentrations in swimming pools and their correlation with the respective disinfection method applied. Also, perchlorate concentrations in *in situ* devices, which have become a focus of health authorities in recent years, is addressed.

CHEMICAL INDICATORS FOR POOL WATER QUALITY

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Pool water preparation goals aim on the provision of clean and safe water for bathers. However, next to microbiological contaminations chemical compounds and residues play an increasing role. Chemical parameters for the general analysis of pool water pollution include Potassium Permanganate Index (PI) for the analysis of organic contaminants. However, in many fields Total Organic Carbon (TOC) analysis has replaced PI. Organic compounds in pool water are oxidized and modified by chlorine necessary for pool water disinfection. Nitrates for example, are formed in elevated concentrations through oxidation processes of nitrogen containing compounds in the water, and combined chlorine might be a predecessor of nitrate. Regarding halogenation products, Trihalomethanes (THM) are known since long as important disinfection-by-products always present in certain amounts whilst others like Cyanogen Chloride are not in focus and probably behave differently as compared to THM. Finally, other compounds like chlorate are mainly introduced into the water as impurities of preparation chemicals. Their concentration can reach enormous amounts, nevertheless, they are not really of public concern up to now. This paper is targeting on a definition and description of chemical process indicators for pool water preparation. To this end, 139 pools have been analysed for all parameters indicated in DIN19643. Altogether 607 datasets from 2019 (before Corona) have been analysed. Results indicate that PI in pool water is lower than in filling water, and that PI will be reduced by water preparation. TOC, however, is lower in filling water than in pool water and is not significantly reduced by water filtration. Analysis of data indicates a correlation between chloroform concentration and TOC, although chloroform is a volatile parameter basically not stable in the water. Combined chlorine seems to be a statistically significant indicator for halogenation products, whilst concentrations of chloride seem to be statistically correlated to chlorate concentrations but not to organic contaminants, like published in literature. We conclude that chemical process indicators may be used to assess chemical water quality and to classify the degree of water conditioning. However, although there are clear connections between parameters from a statistical point of view, individual analyses need to be interpreted with knowledge about the relation of individual parameters.

Session III

Sustainable innovation in water and air treatment

Chairpersons

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MEASUREMENTS AND MODELING OF CHEMICAL IAQ DYNAMICS IN INDOOR POOL FACILITIES

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Chlorination of swimming pool water results in formation of numerous volatile disinfection byproducts (DBPs). Of primary importance among these compounds is trichloramine (NCl_3). NCl_3 transfer from the liquid phase to the gas phase can result in unacceptably high NCl_3 concentrations in the air above and around indoor swimming pools. NCl_3 is an irritant of the respiratory system, eyes, and skin; it also promotes corrosion of metallic surfaces. Transport of CO_2 from the liquid→gas phase is also controlled by mixing in the liquid phase. As such, CO_2 may serve as a surrogate for NCl_3, or more broadly for chemical IAQ in indoor pool facilities. With these facts in mind, a study was initiated to characterize and quantify chemical IAQ dynamics in indoor swimming pool facilities. Experiments were conducted at a number of swimming pool facilities to quantify the dynamic behaviors of NCl_3 and CO_2 in the air and water of these pools. Measurements were also collected to define fundamental aspects of water chemistry, swimmer (and non-swimmer) numbers, as well as characteristics of the Heating, Ventilation, and Air Conditioning (HVAC) systems. The results of these measurements provided clear and consistent evidence of the dominant role of swimmers in controlling chemical IAQ. Specifically, peaks of gas-phase NCl_3 and CO_2 corresponded with peaks in swimmer numbers in the pool facilities. Respiratory activity of swimmers and non-swimmers as well as ambient CO_2 also contributed significantly to the dynamic behavior of gas-phase CO_2 in the pool facilities. Numerical models were developed based on principles of mass conservation to simulate the dynamic behaviors of gas-phase NCl_3 and CO_2. The models included terms to account for net transfer from the liquid→gas phase attributable to background (ambient) water circulation and the effects of mixing caused by swimmers. The models also included terms to describe advective transport into and out of the air space by the HVAC system. In the case of CO_2, terms were also included in the model to account for CO_2 introduction attributable to the respiratory activities of swimmers and non-swimmers in the facility. The models were able to capture the main features of measured dynamic behaviors of NCl_3 and CO_2. As such, it was concluded that the models account for much of the physical and chemical behavior that governs chemical IAQ dynamics in indoor pool facilities. The calibrated models were then applied to simulate the effects of engineering interventions designed to improve chemical IAQ in indoor pool facilities. Specifically, the models were applied to simulate the dynamic behavior of gas-phase NCl_3 in a swimming pool under a hypothetical bather loading schedule. The

models were used to examine the effects of increased air flow (*i.e.*, an increase in the number of air changes per hour) and air stripping on NCl_3 dynamics for the hypothetical scenario. The NCl_3 model revealed that intermittent use of these control measurers can be effective for controlling chemical IAQ dynamics. As such, the model can be used as a tool by pool designers and operators to inform IAQ control strategies.

RELEASE OF PARTICLES AND BACTERIA INTO SWIMMING POOL WATER BY BATHERS AND THEIR REMOVAL IN WATER TREATMENT

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In a swimming pool, bathers release dissolved organic and inorganic matter, particles, and microorganisms into the pool water. There are various process combinations for the treatment of swimming pool water, while typical treatment processes include coagulation, filtration, sometimes UV irradiation, and chlorination. In coagulation, dosage of di- or trivalent metals (most often aluminium) shall compensate negative charges, thereby help to form particle agglomerates, and to incorporate them into flocs. During filtration, particles shall be removed from the water in addition to the coagulated flocs. Often, sand and activated carbon filters are combined for this purpose, with the focus on a high filtration rate, also known as rapid filtration. One of the characteristics of rapid filtration is regular backwashing to remove the accumulated particles. After backwashing, filter ripening takes place. During the ripening phase, particle concentrations in the filter effluent are higher than during the filtration phase. Therefore, a filter-to-waste-time must be incorporated into the filter runs, to avoid high particle concentrations to be returned to the pool. The primary objective of this research was to gain understanding about the effect of bather load and of the water treatment system on the particle and bacteria concentrations, and dissolved contaminants in the pool. For this purpose, data on the number of bathers in the pool as function of time were obtained from a drowning detection system. For particles, concentrations and size distributions are measured semi-continuously using an automatic particle counter. Bacteria concentrations were measured as total and viable bacteria using an automatic flow cytometer. Results show that the number of bathers in the pool has an almost immediate effect (about 0.5 hours delay) on the particle and bacteria concentrations in the entire system. The measurements also demonstrated that the operation of the water treatment system impacts the concentration of particles in the pool. Backwashing of the filters clearly increased the particle concentration in the pool water. This is obviously due to insufficient filter to waste time after backwashing. The discontinuous measurements show that dissolved organic substance are exclusively only removed in the granular activated carbon filters. However, urea, which is a contaminant introduced into the water by the bathers, is not at all removed by the treatment system. Removal of dissolved organic substances mainly concerns natural organic matter introduced by the filling water.

EFFECTS OF TEMPERATURE ON FORMATION POTENTIALS OF TRIHALOMETHANES AND HALOACETIC ACIDS IN CHLORINATED MODEL BFA

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The water temperature of indoor swimming pools is regulated to 26-28°C in Turkey. Also, SPA temperatures generally ranged between 36 and 45 °C. The increase in perspiration rate at high temperatures may increase the anthropogenic disinfection by-product (DBP) precursor concentrations. Also, higher levels of DBP formation might occur with increasing the chemical reaction rate. High temperatures increase the escaping tendency of volatile by-products (such as trihalomethanes and chloramines) from pool water to indoor air. Volatilization of toxic DBPs increases swimmers/bathers and pool staff's inhalation exposure. Public health mitigation efforts should not only focus on lowering exposure through the optimization of HVAC systems, but also on the formation drive parameters of toxic by-products. Body Fluid Analog (BFA) was prepared according to the recipe of Kanan and Karanfil (2011). BFA was diluted to arrange TOC to 5 mg/L. Formation potential experiments were conducted at 27°C and 40°C in a heated water bath. The chlorine dose and pH were 0.5 mg/L and 7.5, respectively. THM and HAA samples were processed according to EPA 551.1 and EPA 552.2, respectively, and analyzed with GC-ECD (Agilent 6890). The highest THM formation in model BFA was determined to be 63 µg/L at 40°C and 120 h reaction time while those was 46 µg/L at 27°C. Half of those THMs were formed at first 16 h both at 27°C and 40°C. THM formation at 40°C was 27% higher than that at 27°C. Like THM formation, the highest HAA formation increases with increasing temperature and reaction times. While HAA concentration at 40°C and 120 h was determined to be 141 µg/L, HAA concentration was determined to 117 be µg/L at 27°C. Kanan (2010) determined that the HAA and THM formation at 40°C were 60% and 200% higher than at a lower temperature. Those differences might be due to Kanan's high TOC concentration (6 mg/L) and chlorine dose (50 mg/L). However, both of high and low precursor concentrations and chlorine dosing cause increasing the formation of THMs and HAAs.

ADVANCED SENSING STRATEGIES FOR WATER MONITORING

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Water is one of the most important human resources hence its quality control for every application in human life is a main concern. Traditional methods for water monitoring are based on lab analysis (spectrometric, chromatographic, enzymatic, etc.) which provide exhaustive speciation and quantification of organic and inorganic contaminants. However, these techniques have a lot of drawbacks such as: expensive fabrication; reagents/probes consumption after long usages; lab constraining, due to the bulky instruments, personnel specialization and the need of multi-step analysis (from water sampling to data processing), avoiding any portable application. The research in this field is moving toward portable instrumentation for fast analyses and even for real time monitoring. In this overview we will present some sensing systems we developed based on miniaturized devices and miniaturizable systems. To this purpose we used a very sensitive photodetector, the Silicon photomultiplier (SiPM), able to detect even a single photon, to fabricate optical sensing systems, potentially portable and useful for real time monitoring. They were applied to the detection of bacteria, hydrocarbons, sulphite, and heavy metals (i.e. Hg) contaminants in water. In some cases the optical detection was coupled to the use of engineered bacteria, able to produce bioluminescence when in presence of a specific contaminant (e.g. Hg), or in presence of toxic substances, opportunely modified bacteria can alert on environmental stress by decreasing their bioluminescence constitutively expressed. Finally, electrochemical devices, in particular screen printed electrodes, were opportunely functionalized to monitor N-compounds (nitrites, nitrates, ammonia) and emerging pollutants. The various systems sensitivity and kinetics are reported and the results obtained discussed.

THE INFLUENCE OFOUTDOOR TEMPERATURE ON NORWEGIAN SWIMMING HALL ENERGY CONSUMPTION

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Research in building energy efficiency, indoor environmental quality, occupant well-being, and its intersection with the outdoor environment has recently expanded due to concerns about climate change and increased outdoor air pollution events (including wildfire smoke, smog, etc..). With around 36% of energy consumption being related to buildings, examining these systems will aid in the effort to decrease global energy consumption. Indoor swimming halls have historically consumed a large amount of energy compared to other commercial buildings. In simple terms, they operate like small factories requiring extensive heating and treatment for both indoor air and indoor water systems. Also, because indoor building and outdoor environments are related, it is of particular interest to examine how outdoor climates affect sport facility energy consumption. This paper investigates the Final Annual Energy Consumption (FAEC) observed by 20 different swimming halls in Norway across three recording periods (2017, 2018, and 2019) and compares these observations with outdoor temperature conditions. First, a multiple linear regression model is fit to the FAEC records, then, this model is compared to that of the climate normalization equation provided by Enova. Preliminary analysis finds a significant correlation between facility end-of-use energy consumption and two predictor variables: pool water surface area (ws) and outdoor mean annual ambient temperature. For the swimming halls examined, data indicates that 30% of FAEC is attributed to geographical climate and the thermal performance of the building envelope, whereas 70% of FAEC is related to process installations. That is, the majority of FAEC is consumed by facility infrastructure, thus selecting energy efficient pool electrical equipment, pumps, HVAC units, and treatment system systems will lead to the greatest energy savings. Furthermore, introducing conservation measures early in the facility planning and development stage is vital to reducing FAEC. This study's methodology can be used as input to benchmark swimming hall energy consumption and to project future energy demands.

INCREASING SWIMMERS HEALTH AND THE QUALITY OF WASTEWATER BY USING A TRIPLE ELECTRO-DISINFECTION SYSTEM AS ALTERNATIVE FOR CHLORINE: THE RESULTS IN TEN BELGIAN PUBLIC SWIMMING POOLS

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It is already widely known that chlorine and its by-products cause health problems among elite swimmers (see lit.), pool workers (see lit.) and pose a potential danger to babies and young children (see lit.). High levels of AOX in wastewater are also increasingly considered of concern by many governments. Alternatives to chlorine have been investigated but show insufficient disinfection capacity for application in public swimming pools, lack proof of efficiency or are very expensive. Moreover, they always involve the use of chemicals (such as hydrogen peroxide) or gases (such as ozone), which are potentially dangerous. Many pool managers therefore resort to higher ventilation and more fresh water to keep chlorine levels low. This, too, is a very expensive solution. The electro-disinfection system developed by Prof. P. Lievens (P. Lievens, J. Van den Bulcke: 2015, 6th Swimming Pool & Spa conference, Amsterdam) shows that swimming can be done safely with less chlorine. Following this study, several pilot projects were started under the supervision of the Belgian-Flemish Health Agency. A triple electro disinfection system was installed in different types of public pools: 25m pools, recreational pools and paddling pools. The system is combining electrochemical disinfection, UV and copper disinfection. In all pools it showed a spectacular decrease in chlorine levels and its by-products in air, water and wastewater. The following range of values were recorded: trichloramine in the air 75-144µg/L, free available chlorine 0,20-0,50ppm, bound chlorine 0,05-0,26 ppm, chlorate 5-15mg/L, THM 9-14µg/L, and in the wastewater AOX <250µg/L. The triple electro-disinfection system proves its safety and efficiency in real life situations without the production or use of gas or chemicals. It has been tested and approved by the Belgian-Flemish government for use in all public swimming pools.

Session IV

Panel Discussion: Water treatment and management for Thermae, Wellness, Bio-pools

Chairpersons

Marco Vitale, Vincenzo Romano Spica, Federica Valeriani

HOT SPRINGS SANITATION: TOWARDS GLOBAL BEST PRACTICE

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Natural geothermal mineral waters have been used for health and healing since the dawn of humanity and have now given rise to a multi-billion-dollar global industry that focuses on health maintenance, prevention, and treatment, along with entertainment and relaxation. The mechanisms underlying the benefits of geothermal waters remain unknown and likely arise from multiple factors including the unique properties of natural spring waters which vary with location, source, flow rate, physicochemical properties, mineral composition, and microbiota, along with subtle properties that are not yet fully understood. While bathing in natural mineral waters confers health benefits, it also poses risks due to naturally occurring and/or human-introduced pathogens. The risk of pathogen-induced illness varies with water quality, water flow, exposure to microbial sources, dilution of contaminants, the design, maintenance and monitoring of facilities, along with bather-load. The demographics, health status, hygiene practices and behaviour of bathers are also important risk factors. The risk of microbial-borne illnesses makes the measuring, monitoring, and managing of microbial activity in geothermal waters an issue of significant economic, operational, regulatory, clinical and public interest, yet current regulations are currently fragmented and inconsistent and lack a strong evidence-base. Regulation of natural waters vary widely with respect to flow rates, disinfection use, and the maintenance and monitoring of bathing facilities. Furthermore, while some regions consider natural waters 'untouchable', other regions require the addition of residual disinfection with chlorine, which can be problematic as chlorine changes the inherent properties of natural waters and chlorine is volatile making it less effective in warmer waters. Chlorine also irritates the skin and mucous membranes, oxidises natural body oils, and forms toxic disinfection by-products that directly enter the bloodstream through dermal absorption and inhalation. Furthermore, chlorine reduces water's sensory properties, and inhibits the activity of potentially beneficial microbes while being ineffective against pathogens such a cryptosporidium and giardia. Historical and empirical data along with modern scientific study suggests the safety and integrity of natural waters can be respected by maximising flow rate and dilution, while minimising pathogen exposure through effective cleaning and hygiene practices. The adoption of general principles for measuring, monitoring, and managing bathing facilities can guide regulators and operators to provide safe and healthy facilities that enhance bather experience, minimise risk to bathers and the environment, and provide assurance to investors, insurers, clinicians and the public that bathing in natural mineral waters can be safe without compromising social, economic and health benefits.

PRESENCE OF LEGIONELLA IN THERMAL WATERS: 16 YEARS OF SURVEILLANCE. THE ISSUE SET IN THE ONE HEALTH VISION

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Thermal establishments comprise a wide spectrum of recreational and therapeutic activities with a number of customers that have increased overtime despite the stop occurred during the first phases of the COVID-19 pandemic. In order to evaluate the potential role played by this setting in the risk to get legionellosis, we conducted a cross-sectional study to evaluate the presence of Legionella spp. in some Italian thermal establishments. Specifically, we retrospectively analyzed the results of a 16 years' surveillance carried out before the COVID-19 pandemic. Of 409 samples, 70 (17.1%) were positive to Legionella spp. but with an overall decrease overtime. *L. pneumophila* 2-14 were by far the most common detected serotypes while *L. pneumophila* 1 accounted only for 8.8%. Of all the different kind of samples, swabs and municipal water samples were the most contaminated ones. Moreover, in the positive samples, bacterial load was often at intermediate values. Only in a little percentage of samples load was high and, in this case, *L. pneumophila* 1 was often the most interested strain. Our results show the importance of a continuous monitoring of Legionella risk in these setting even more so now after the COVID-19 pandemic and the prolonged stop of the activities. As water is the natural environment of Legionella spp., and environment in general plays a crucial role in the transmission of these bacteria, it would be useful to frame this infection in a "One Health" key.

EFFECTS OF MUD-THERAPY ON PAIN, FUNCTION AND QUALITY OF LIFE IN PATIENTS WITH RHEUMATIC AND DERMATOLOGIC DISEASES: A SYSTEMATIC REVIEW

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Introduction. Mud-therapy is frequently used as non-pharmacological treatment for rheumatic and dermatologic diseases. Mud can be used as a local (mud-pack) or general (mud-bath) treatment. Despite its long history and tradition, its biological action and its clinical effectiveness are still not clear. The objective of this review is to synthesize the current evidence on mud therapy's effects on pain, function and quality of life in patients with rheumatic and dermatologic diseases.

Methods. Databases, such as PUBMED, EMBASE, MEDLINE, CENTRAL, Scopus and PEDRO, were searched for articles published from January 2000 to November 2021. Articles were included if published in English or Italian.The review included articles on the effect of mud-therapy alone or combined with drug therapy or thermal water baths or physical therapy or other conventional therapies in adults (18 years and over) with rheumatic and dermatologic diseases. The main outcomes were pain, function, quality of life and adverse events. Randomized clinical trials, non-randomized trials, and comparative cohort (prospective and retrospective) that compared mud-therapy to no intervention or to other intervention were eligible if they assessed at least one of the main outcomes. Non-comparative case series (single arm) and case reports were also included for safety outcomes assessment only.

Results. A total of 5512 records were identified from the selected databases with the predefined search strategy. After removing duplicates, 3332 studies were screened by titles and abstracts. One hundred fifty-one records were under review for the full-text and 76 studies were included. Selected articles were stratified by diseases: 44.7% knee or hand osteoarthritis, 28.9% generalized or spinal osteoarthritis, 7.9% autoimmune diseases, 1.3% compressive diseases, 2.6% tenosynovitis, 5.4% fibromyalgia, 6.6% dermatologic diseases. Two remaining studies considered multiple diseases. Preliminary analysis showed an improvement in 29 out of 35 (82.9%) articles that evaluated quality of life in adults treated with mud-therapy compared to any other intervention or to no intervention; this improvement was reported as significant in 54.3% (19/35). Similar evidences were found in studies that evaluated function (36/48, 75.0% of improvement; 28/48, 58.3% of significant improvement) and pain (37/46, 80.4%; 31/46, 67.4%, respectively).

Conclusions. Although the included studies were heterogeneous in terms of interventions and comparators, our first analysis suggest a therapeutic effect of mud-therapy for rheumatic and dermatologic diseases. These results are still preliminary and it is necessary the analysis completion in order to reach definitive conclusions on the current evidences.

NEW EVIDENCE ON THE MECHANISM OF ACTION OF BALNEOTHERAPY

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Balneotherapy (BT) is one of the most commonly used complementary therapies for many chronic conditions. Its beneficial effects are related to physical, chemical and microbiological factors, but the exact mechanism of action is not fully understood. A distinction can be made between non-specific and specific mechanisms. Non-specific or hydrotherapic mechanisms are ascribable to the physical properties of the water and are commonly related to the simple baths in hot tap water, while specific effects depending on the organic and inorganic compounds as well as on the community of microorganisms present in mineral water, in mud, or in other peloids with therapeutic properties. The body of evidence substantiating the effectiveness of BT has been increasing progressively during the last decade with a number of preclinical and clinical studies which can allow us to better understand the mechanisms by which BT induces beneficial effects. Results obtained by human studies demonstrated a reduction of circulating levels of different mediators and factors of inflammation, oxidative stress, cartilage metabolism, and humoral and cellular immune responses. Mud baths therapy is also associated with a decrease in serum levels of adiponectin and resistin, and with a positive modification of the expression levels of a pattern microRNA implied in the progression of chronic degenerative diseases like osteoarthritis. Indeed, balneotherapeutic treatments can increase serum β-endorphins and can modulate cortisol levels in such a way as to improve individual stress resilience without disrupting circadian rhythms of this hormone. Furthermore, transcutaneous absorption of antiphlogistic substances released by water and mud microflora may contribute to the overall pharmacological effect of BT. More details about possible mechanism of action of balneotherapy, as hypothesized on the basis of preclinical studies on cellular cultures. In particular, *in vitro* evaluation on keratinocytes, support the beneficial effects of balneotherapeutic treatments, especially those ones based on sulfur-rich waters, on skin diseases, such as psoriasis. *In vitro* studies on fibroblast-like synoviocytes, chondrocytes, and osteoblasts demonstrated the anti-inflammatory, antioxidant and chondroprotective effects of H2S donors corroborating the value of sulfur water in the treatment of different rheumatic conditions. Moreover, the sulfide compounds seem to regulate inflammation and immune response in purified human peripheral blood neutrophils, eosinophils or lymphocytes. Globally, the mechanism of action of BT, although not fully understood, seems to be sustained by a synergistic action of the different components of natural mineral waters and/or mud-packs.

RISK FOR MAINTENANCE OPERATORS IN CONFINED SPACES AND/OR SUSPECTED OF BEING POLLUTED IN SWIMMING POOLS, SPAS AND WATER TREATMENT FACILITIES. INDICATION OF THE ENVIRONMENTS AT RISK AND POINT ON THE QUALIFICATION OF THE OPERATORS

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In swimming pools, Spa$_s$ and water purification facilities, operators who are dedicated to the maintenance of the facilities may be exposed to various types of risks. Among these risks, the one that is more complex to manage and in some cases is less known to the workers themselves is that deriving from activities that take place in confined spaces and/or environments suspected of pollution. They are intended for confined and/or suspected of pollution environments according to a definition of the NIOSH "Confined Space" (2015); it refers to a space which, by design, has limited openings for entry and exit, unfavourable natural ventilation which could contain or produce or accumulate dangerous volatile contaminants, and which is not intended for continuous worker occupancy. The presence of harmful substances for people such as chlorine, sodium bisulphite, sodium hypochlorite, sulfuric acid, make an adequate risk assessment activity necessary. Here, several issues will be considered to identify the different environments where operators can be exposed to dangers and consequent health risks, deriving from confined environments and/or environments suspected of pollution; and to define the qualification criteria that these operators must fulfil in order to gain access to these environments.

Session V

Biological Risk

Chairpersons

Regina Sommer, Apostolos Vantarakis

ADVANCED APPROACH FOR ASSESSING SAFETY AND QUALITY OF THERMAL WATER AND MUD

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Spa waters are used for therapeutic or recreational purposes, in form of bath, hydromassage, aerosol, and mud. Thermal waters have specific therapeutic properties associated with their chemical and physical characteristics. Also, the microbial diversity of these waters can contribute to their curative effects. Thermal muds (peloids) are produced by maturation of clayey materials in thermo-mineral waters and their peculiar healing properties depending on the kind of clay minerals, the physico-chemistry of thermal waters and the growth and colonization of microorganisms during the maturation process. On the other hand, thermal waters may represent a potential health risk since temperature, pH, morphological characteristics of spring, presence and concentration of typical salts can create habitat suitable for the survival and multiplication of opportunistic bacteria, such as *Legionella* spp. The assessment of water quality and safety has been traditionally performed by culturing microorganisms from water samples. Recently, new molecular techniques able to discriminate between viable and dead cells have been developed. Moreover, the diffusion of Next Generation Sequencing (NGS) and bioinformatics tools offers the opportunity for a more extensive approach for examining the microbial diversity. By analysing the microflora DNA it is possible to detect not only single bacteria, but, simultaneously, all the different species interacting in an ecological niche. In this context, our research activities have focused on evaluating the presence of viable legionellae inside thermal water networks, using traditional culture and molecular methods, such as qPCR and EMA-qPCR, and characterizing, by using NGS technologies, the microbial community of thermal waters, moving from spring to points of use, and of peloids during the different stages of maturation within an Italian spa complex. Sequencing-based microbial community analysis associated with viability qPCR can provide information about the presence of waterborne opportunistic and/or pathogenic bacteria in order to select effective control measures aimed to guarantee the best water quality and safety for the people attending the thermal facilities. Moreover, our investigation approach based on the NGS technologies can significantly improve the knowledge on relationship between microbial composition of both thermal waters and muds and their peculiar therapeutic and cosmetic properties, allowing also to identify a kind of biological signature characterizing a thermal spring.

PUBLIC HEALTH RISKS RELATED TO THE USE OF SWIMMING POOLS IN ALBANIA

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Abstract. The first swimming pool complex in Albania was built in 1985 in the city of Tirana, this year also corresponds to the issuance of the First Regulation by the Ministry of Health. The regulation issued on 10.05.1989 for the hygienic-sanitary requirements of swimming pools, which contained general rules on the duty of the state sanitary inspectorate in the control and implementation of hygienic-sanitary rules during the design, construction and operation of swimming pools, this was the first chapter of regulation, these pools did not have complete structures and are generally considered outside the control of the state sanitary inspectorate structures.

Purpose. Evaluation of the quality of recreational waters (swimming pools).

Design/methodology/approach. The study was a pilot, analytical cross-sectional study. The number of pools taken in this study was 12 pools (6 open and 6 closed pools) in Tirana and Durres city. The number of samples for closed pools was about 200 (during the period of use, October, November, December and January), while for the pools open 222 samples (during the entire summer season of operation - May, June, July, August and September).

Findings. Poor quality water in the studied pools; the methodology of "self-control" and recording of concrete data is not applied; not all relevant rules have been implemented in their design and construction; there are deficiencies in the maintenance and disinfection of environments; lack of used water discharge systems, for the controlled drainage of waters containing various pollutants; lack of chlorine use before and after using swimming pools, etc.

PREVENTING STRATEGIES TO CONTROL *LEGIONELLA* PROLIFERATION INTO WATERLINES OF SPAS AND SWIMMING POOLS

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Legionella pneumophila is a ubiquitous microorganism naturally present in water environments, which is responsible for several travel-associated Legionnaires' disease cases annually occurring in Europe. Except from the most obvious sites (cooling towers and hot-water systems in health facilities), infections have also been associated with recreational water feature and garden areas of hotels, spas and swimming pools. This argument is of great interest to better comprehend the colonization and to calculate the risk to human health of these sites. The actual presence of this opportunistic premise-plumbing pathogen in recreational swimming pools, hot tubs and other recreational waterlines has been associated to the absence of a suitable Water Safety Plan implementation and the concomitant presence of poor sanitary conditions. High risk was estimated for pool showers, garden sprinklers and pool water when disinfection treatments were not effective and other preventing strategies, including physical treatments of water and waterlines, environmental surveillance and microbiological monitoring, were not applied. In the present study, the relative effectiveness of different preventive strategies against *Legionella* re-growth in waterlines are discussed and compared. In particular, the following factors have been shown to be effective in reducing the prevalence of microbial contamination: a free chlorine concentration ≥2 mg/l or a total bromine ≥3 mg/l, an oxidation-reduction potential >650 mV and a turbidity ≤1 NTU. Carefully selected materials, good circuit design, and good maintenance practices have been considered to be critical for preventing *Legionella* colonization by disinfection treatments. Moreover, a satisfactory microbiological quality over time has been achieved and maintained by introducing a UV/ultrafiltration system.

EFFECTS OF BUBBLES IN PREVENTING THE PROLIFERATION OF PATHOGENS ON MATERIALS USED FOR SWIMMING POOLS

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Bubbles are widely used in the food industry as a means for vegetable washing. In the last years, their use has been extended to different cleaning processes with the goal to avoid the use of chemicals. In fact, it was proved that bubbles can cause the biofilm to detach from a surface when they hit or slide along it. The proliferation of biofilm adhered to the surfaces of a swimming pool is a real risk, especially in presence of poor water recirculation or disinfection. The present research aims at assessing the efficiency of bubbles in removing the biofilm from the materials typically used to build a swimming pool. The scale model of a swimming pool formerly used for investigating the bacteria proliferation on different materials for swimming pools was equipped with a grid of porous pipes to insufflate compressed air in form of bubbles. Samples of different materials, including that of the porous pipes, were contaminated by means of bacteria and placed above the porous pipes inside the bubble plumes. A bacterial count was performed after the sample exposure to the bubbles and compared with those performed before the air insufflation and of blank samples. Data based on the biofilm generated from different microorganisms and under several conditions are reported. The results confirm that bubbles are of interest as an alternative way for biological prevention on the materials used for swimming pool engineering.

USING MODELLING OF CRYPTOSPORIDIUM CONTAMINATION EVENTS TO INFORM PUBLIC HEALTH ACTIONS

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Cryptosporidium is an important waterborne pathogen, and the most common one implicated in outbreaks of gastroenteritis linked to swimming pools. Cryptosporidium oocysts can be shed in faeces of asymptomatic as well as symptomatic bathers. The oocysts can survive typical pool water chlorination for up to 12 days and evade capture by inadequate filtration. The ingestion of single numbers of oocysts presents a significant risk of infection and disease. In England and Wales, where there is systematic surveillance of Cryptosporidium cases and outbreaks, there were 82 pool-related outbreaks reported between 2009 and 2017. To provide innovative data about the occurrence and concentration of Cryptosporidium oocysts in leisure pools we sampled and tested pool water from 6 pools for 10 summer weeks and subsequently modelled oocyst detections and numbers. Those data were then used to inform guidance for pool operators and public health professionals. Oocyst detections were predominantly in August when bather loads were highest. Monte Carlo analysis showed that when high bather numbers caused contamination on over 70% of days, multiple events per day were more likely than single events. By making several assumptions (particularly with respect to the timing of the release relative to the sampling period), it was possible to estimate that the likely numbers of oocysts shed were orders of magnitude less than would be expected from symptomatic shedding events. It is yet to be established what microbial risks are associated with the lower numbers of oocysts shed asymptomatically; this aspect of quantitative microbial risk assessment is currently work in progress. In the generally well-managed leisure pools that we sampled, Cryptosporidium detection risk related to high bather loads. A contamination event of any magnitude is likely to present a greater microbiological risk in a small pool than a large one due to less dilution. In busy pools there are likely to be frequent contamination events, emphasising the importance of water treatment measures to remove oocysts by effective filtration or inactivate them by UV light. In addition, activities aimed at reducing Cryptosporidium contamination should also be promoted. We conclude that public awareness campaigns for bather hygiene, post-infection exclusions, reminding pool operators of current guidance for managing faecal accidents, and health promotion activities should be undertaken ahead of peak swim seasons.

INNOVATIVE NANOHYBRID THROUGH TITANIA AND SILVER NANOPARTICLES CONJUGATION FOR ANTIBACTERIAL APPLICATIONS

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The presence of pathogens in water is one of the major concerns worldwide. These microorganisms can lead to diseases and induce epidemics, therefore there is a need to find sustainable systems for water disinfection. Among the most interesting green technologies are those based on photocatalysis, in which catalytic substances are able, in the presence of light, to generate reactive oxygen substances with antimicrobial capabilities. In this work, a new nanohybrid was obtained by direct conjugation of silver nanoparticles to titania nanoparticles (TiO_2NPs-AgNPs), to achieve synergistic antibacterial activity in a single nanoplatform. For this conjugation process, a bifunctional alkoxysilane linker, (3-mercaptopropyl) trimethoxysilane (MPTMS), was selected to functionalise TiO_2NPs surface, containing both -SH group for the Ag attachment, and oxygen atom, for the TiO_2NPs conjugation, in its structure. This linker can increase the stability and biocompatibility of commercial TiO_2NPs with a size of 50 nm. Moreover, *in situ* AgNPs decoration was achieved using sodium borohydride ($NaBH_4$) as reducing agent in order to have chemical reduction of silver precursor from Ag(I) to Ag(0). A hydrophilic thiol, sodium 3-mercapto-1-propansulfonate (3MPS), was chosen to stabilise and prevent the aggregation of nanoparticles during their growth. The stability, size, morphology, and chemical composition of the as-synthesized TiO_2NPs-AgNPs nanohybrids were evaluated by extensive characterizations including UV-Vis, DLS and ζ-potential, FTIR, FESEM-EDX. These results demonstrated the successful silanisation of commercial TiO_2NPs and subsequent *in situ* AgNPs-3MPS decoration. Furthermore, *in vitro* antibacterial properties of TiO_2NPs-MPTMS@AgNPs-3MPS nanohybrids were performed under controlled conditions and on specific strains - gram-negative bacteria, *E. coli* (10^5 CFU/mL) and gram-positive bacteria, *S. aureus* (10^4 CFU/mL) - exposed for 25 minutes in the presence of visible light and in the dark. These results show over 70% reduction in *E. coli* with exposure to visible light in TiO_2NPs. Assessing the synergy between TiO_2NPs with AgNPs shows over 99.9% reduction ($p=0.05$) for both *E. coli* and *S. aureus* down to a concentration of the compounds three orders of magnitude lower, regardless of light.

RISK ANALYSIS OF OTITIS EXTERNA (SWIMMER'S EAR) IN CHILDREN POOL SWIMMERS: A CASE STUDY FROM GREECE

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Otitis is an ear inflammation characterized by an accumulation of polluted fluids in the ear, inflating the drum, causing ear pain, and draining the mucous membrane (pus) into the ear canal if the drum is perforated. Swimmer's otitis, also known as acute external otitis, is a medical condition that frequently affects competitive swimmers. The risk factor analysis study was based on data obtained between May 2018 and May 2019 from four public swimming pools in Patras, Achaia. A checklist was created to evaluate the pools' operational conditions, and it included information on the pools' sanitation as well as swimming pool hygiene guidelines. In addition, a questionnaire was devised to collect data on pool swimmers' use of the pools. Microbiological testing of the pool water was done ahead of time, and data on external otitis cases from hospitals was gathered. Based on this information, a risk factor analysis was conducted. Gender, weight, and age do not appear to have an impact on the number of otitis media cases that occur because of swimming in the pools. There is also no statistically significant link between episodes and the frequency of otitis events in locker rooms, restrooms, or swimming pools. The frequency with which swimmers utilize the pool, rather than the pool's microbial burden, is the most significant determinant in otitis episodes. Furthermore, there is no statistically significant link between chlorine odor and otitis episodes. Additionally, several abnormalities in the ear or the child's history do not appear to affect otitis episodes. More research is needed to determine whether infections are linked to microbial load or if other factors are responsible for the emergence of waterborne infections.

Session VI

Miscellanea session: sport and physical activity, pool design and management

Chairpersons

Polonca Tresbe, Ernest.R Blatchley III

SAFETY OF SUBMERGED SUCTION OUTLETS IN SWIMMING POOLS

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In the summer of 2022 a Dutch girl (age 9y) drowned in a French pool during vacation after she got trapped with her hair in a suction outlet. Unfortunately, accidents like this happen more often in pools all over the world, while they can be avoided by proper design, maintenance and inspection of swimming pools. The European standard EN 13451-series addresses many health and safety issues in swimming pools, among them the hazards of submerged suction outlets described in EN 13451-3. This En-standard was first published in 2011, and updated in 2016. In 2019, a design of a new EN 13451-3 was published, but was still under discussion with the technical commission and awaiting approval at the day of the fatal accident in France. One day after the accident, the new updated EN 13451-3 was published. Despite the known hazards of these suction outlets, accidents still happen. Apparently, we, the swimming pool community, are not doing enough to avoid these accidents, we need to do better, but what can we do. The EN 13451-3 addresses safety of suction outlets during pool design, so it's only applicable to new swimming pools. How can the EN 13451-3 standard also be used for existing pools and is that enough to avoid future accidents? Or do we even need to go one step further and inform parents of young children in pools as well?

WATER USE MANAGEMENT BASED ON PRESENCE AND ACTIVITY LEVELS OF SWIMMERS IN INDOOR SWIMMING POOLS

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We propose a novel water use management method for swimming pools to optimize the use of freshwater while always maintaining health regulation requirements and water quality. The novel method calculates the amount of freshwater needed to be injected to swimming pools based on presence and activity levels of swimmers. While disinfectant agents like chlorine must be present to kill micro-organisms like algae, the reaction of chlorine and organic/non-organic releases from swimmers generates Disinfection By-Products (DBPs) that some of them are associated with Cytotoxicity and Genotoxicity characteristics. The conventional water management methods require swimming pools to add a certain volume of freshwater per swimmer per day, which disregards presence time and activity level of swimmers. This especially becomes inefficient for swimmers who come for a short time and/or with low activity level and insufficient for athletes who have high activity levels. In our proposed method, the amount of body fluid release and water evaporations are estimated per each short period based on presence and activity levels of swimmers, and the amount of generated DBPs and other substances are estimated over time. The predicted amounts of DBPs and other substances are used to schedule adding a volume of makeup freshwater and draining wastewater. The performance of the proposed water management method, compared to the conventional water management methods, is evaluated using simulation and validation on a pilot small scale swimming pool.

DYNAMIC WATER QUALITY MODELING FOR IMPROVED POOL DESIGNS AND SAFER REGULATIONS

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By combining fundamental equations, laboratory measurements, and published data, a new platform for modeling water quality in pools and splash pads was developed. It is now possible to quantitatively model the turbidity, UV-254 absorbance, and *Cryptosporidium* concentration over time based on the type of treatment system, turnover rate, water chemistry, and bather load. It is possible to quantify and compare water quality trends based on design or operational changes. For example, the water quality can be predicted based on a change in the turnover time, switching filters, and/or adding a UV disinfection system. The *SuperModel* program will allow designers, regulators, manufacturers, researchers, and operators to make informed decisions about managing water quality, risks, costs, and capacity limits. Contaminant loading events are based on research measurements of swimmers on a per bather basis. Similarly, the filter performance is based on full-scale filter measurements. Accidental Fecal Releases (AFRs) and pathogen sloughing can both be simulated over a 7-day period of pool operation. Simulations demonstrate that as filter efficiency varies from 22% (worst-case scenario) to 99% (best-case scenario), the pool's turnover rate can be decreased to compensate for inefficient filters. Some filtration, chlorination and turnover combinations could return a pool to "safe levels" within 24 hours of an ARF, while alternate designs could take a week or longer. Up to five simulated pool designs can be compared with the same bather load over a 7-day period to detect contaminant accumulation in the form of turbidity, *Cryptosporidium*, or organics (as measured by UV-Absorbance). Simulations could predict the maximum bather load for a variety of pool designs. Splash pads, with the relatively large numbers of bathers per volume of water could see rapid accumulation of turbidity and organics that could impair UV or other disinfection systems leading to increased risk of waterborne disease outbreaks. Pool designers and regulators could make better decisions about the relative performance of different design alternatives. It can be shown that poor filter efficiency can be partially or completely offset by decreasing the turnover time, which can be visualized using the *SuperModel*. For example, a filter operating at 98% removal efficiency with a 6-hour turnover would perform identically to a filter operating at 24.5% removal efficiency with a 1.5-hour turnover (because competing values were decreased by a factor of exactly 4). However, filter efficiency, turnover time, and chlorine chemistry are not currently used in setting government regulations or in setting maximum bather capacities for aquatic facilities.

THE EFFECT OF INDIVIDUAL, GROUP AND AQUATIC EXERCISES ON HEALTH-RELATED QUALITY OF LIFE IN OLDER PEOPLE LIVING IN RESIDENTIAL CARE SETTINGS: PRELIMINARY RESULTS FROM TWO ITALIAN REGIONS

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One of the most sensitive events in the life of an elderly is represented by the entrance to a Residential Care Facility (RCF). For institutionalized individuals, maintaining autonomy and a good physical, mental and social health is crucial, and this can be achieved through a multidisciplinary approach. A growing literature shows that, in RCFs setting, exercise and multicomponent Physical Activity (PA) programs can have beneficial effects on these outcomes, in particular on mental health and cognitive functions. Aquatic exercise could also be a promise intervention in RCFs. The aim of the study is to describe the diffusion of exercise programs in a sample of Italian RCFs and its impact on the health-related quality of life (HrQoL). Eight RCFs belonging to Marche and Emilia Romagna Regions (Italy) were included in the study. HrQoL was assessed using the Short-Form 12 questionnaire (SF-12). Preliminary results from 89 older adults (age: 84.33±8.36, 78.7% women) showed that 51% of participants performed at least 1session of individual PA per week and about 70% of participants performed group PA. Only 3% of participants performed aquatic exercise and 10% did not engage in any type of PA. Considering the HrQoL score at baseline, a higher Mental Component Score (MCS) of SF-12 was observed in patients carrying out more PA group activity (>2 times per week) MCS=48.91±9.90 than in those who practiced less (≤2 per week) 43.68±10.08 p=0.03. Considering the individual PA, we observed higher scores of MCS in patients carrying out more sessions: 48.95±10.92 (>2 individual PA per week) versus 45.66±9.21 (≤2 individual PA per week), p=NS. On the contrary, the Physical Component Score of SF12 remained unchanged based on PA frequency and modality. These results highlight that, in general, group PA was offered more frequently than individual activity in RCFs. Further, despite the potential benefit of aquatic exercise, this activity is not common in RCFs. Our data confirm that continuous group exercise is associated with higher mental wellness among elderly. These results also underline the importance of PA-based-interventions in this specific setting in order to improve the HrQoL of this vulnerable population.

SWIMMING POOL RELATED HEALTH COMPLAINTS: NOT JUST WATER AND AIR

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Sometimes swimmers and instructors experience health complaints in a swimming pool. Individual problems are often ignored or not noticed. But when they come in clusters, investigation becomes more important. The Outpatient Clinic for Swimming Pools and Spas Amsterdam is specialised in investigating health complaints in relationship with swimming pools. Recently the clinic worked on cases concerning in which a new system of air conditioning caused the problems. This system uses air quality as third control parameter besides temperature and humidity. Although most complaints were solved by returning to a classical system of air conditioning, this turned out to be only part of the problem. Underlaying conflicting interests, poor communications and a bad working atmosphere dominated the process of trouble shooting.

EXAMPLES OF TECHNOLOGICAL SOLUTIONS USED IN POLAND IN THE FIELD OF REDUCING THE OPERATING COSTS OF SWIMMING POOL FACILITIES

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Rationalization of water supply sources in in terms of water purchase costs is the basic way to reduce the operating costs of these swimming pools. The most common type of water supply solution for such facilities is the provision of water by local waterworks. However, facilities that have invested in their own water sources, e.g. wells, or use water from open watercourses or lakes to fill and replenish swimming pools, operate successfully. A very good example in this regard is the Olympic swimming pool of the Municipal Sports and Recreation Center in Oświęcim, where the pools are filled and supplemented with water from a lake. The cost of such a pool water supply can be as little as 10% of the cost of water purchased from local waterworks. The latest projects implemented in Poland in this area concern attempts to use rainwater in swimming pool installations (e.g. Aqpar in Wrocław). These solutions are in line with the global trends of actions taken in the field of circular economy. This technology is a complementary solution to the two currently identified problems and comprehensively approaches the issues of both rational water management in cities and reducing the operating costs of swimming pool facilities. Poland is one of the countries most at risk of a water crisis. The problem of water scarcity is also deepening not only due to rising temperatures, but also due to the lack of management of heavy rainfall. It has been calculated that during a 20-minute rain, up to 360 liters of water can be collected from a 120 m² roof, which can be reused. Rainwater in modern environmental engineering is very often wasted by immediately discharging it to the receiver, and yet it is a valuable and free water resource that can be successfully used for many different purposes. The current EU regulations even recommend that water management should be carried out in accordance with the principle of sustainable development and rational and comprehensive treatment of groundwater and surface water resources, taking into account their quantity and quality. In order to limit the adverse phenomena, they are related to the drainage of rainwater, so new, alternative methods of their management are sought all over the world, such as blue-green infrastructure design solutions.

Session VII

Risk assessment and Management in swimming pool and similar environments

Chairpersons

Janice Calvert, Osvalda De Giglio

CHLORINE SENSITIVITY OF GRAM-POSITIVE AND GRAM-NEGATIVE BACTERIAL STRAINS UNDER SWIMMING POOL CONDITIONS: MICROBIAL PROCESS INDICATORS FOR POOL WATER DISINFECTION

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Disinfection of swimming pool water is mandatory to avoid spreading of infectious diseases. If chlorine concentrations in the pool water are too low, certain organisms might survive or only be injured and able to recover. If chlorine concentrations are too high elevated concentrations of disinfection by-products might be formed. According to DIN19643, *P. aeruginosa* is used as a process indicator which should drop under the influence of the disinfectant by four orders of magnitude within 30s. Actually, routine data from our lab indicate that this organism is only present sporadically in pool water although chlorine concentrations are low (0.3 and 0.6 mg/L). To elucidate the question how gram-positive and -negative species behave toward chlorine and whether *P. aeruginosa* is an adequate process indicator, disinfection experiments were performed and four different bacterial strains (*B. cereus; S. aureus; E. coli* and *P. aeruginosa*) were compared regarding their chlorine sensitivity. Bacteria were exposed to different disinfection regimes common in pool water. As recommended by OECD, a large ratio of test- to inoculum volume was applied using a 50 L aquarium and 3 ml of inoculum and all basic conditions were under control. During the first minute of the experiment, samples were taken in intervals of 10 seconds; later one sample was taken per minute. Interpretation of results was done using the Chick and Watson and other disinfection models. Inactivation kinetics show remarkable differences between different strains. Whilst for both gram-negative species decay rates increased exponentially with increasing chlorine concentrations, decay kinetics were different for the gram-positive species. For *S. aureus*, a linear and less steep gradient was detected. For *B. cereus*, after an instant drop by two orders of magnitude within 10 seconds, CFU stayed at approximately the same level over the remaining time of exposure. Differences between the individual bacterial strains became even more apparent at different experimental pH settings and constant chlorine level. Whilst inactivation of *P. aeruginosa* follows an exponential decay, *E. coli* and *S. aureus* show sigmoidal curves. For *B. cereus*, after a drop by approximately 2 orders of magnitude CFU level remained nearly constant. Results indicate that under pool conditions gram-positive organisms are significantly more resistant against chlorine than gram-negative bacteria. Additionally, MALDI-TOF analysis of bacteria present in real life pool water samples indicate mostly gram-positive species. We conclude that certain gram-positive organisms are probably more representative as process indicators for pool water disinfection than *P. aeruginosa*.

MICROPLASTICS AND RECREATIONAL WATER

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Microplastics pollution in recreational water has become increasingly prominent and has received widespread attention in the last years. Microfibers, very short textile fibres (less than 5 millimetres long), are the most common microplastics released into water environments. It has been estimated that each year, trillions of microfibres are released into the environment due to the washing of textiles, with most of them ultimately ending up in the ocean. Microfibres from the washing of plastic-based textiles, such as polyester, acrylic, and nylon, have been identified as a major contributor to this problem. The annual market of swimwear strongly contributes to microfibers release. The extended use at the pool or the beach will result in the introduction of microplastic fibres directly into the water. The average swimsuit contains a mixture of manmade fibres, including nylon (polyamide) and either elastane, spandex or lycra (polyurethane) in the outer, with a polyamide or polyester lining. A prolonged exposition to chlorine and salt can compromise the strength of the fibres and promote the breaking. The sun is a problem too. Ultraviolet rays damage the structure of plastic, making fibres more brittle and prone to breaking. There are several environmental and health concerns related to microplastics release. The small size of microplastics results in their uptake by a wide range of aquatic species disturbing their physiological functions, which then go through the food web creating adverse health issues in humans. Recent research reveals that viruses can survive and stay infectious for up to three days by 'hitchhiking' on plastic pollution in fresh water. Thus, its release should be carefully estimated to plan proper policies in the next future.

REDUCTION OF MICROPOLLUTANT CONCENTRATION IN SWIMMING POOL WATER

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Pool water is a separate, complex type of water stream in which both organic and inorganic pollutants are identified. The type and concentration of contaminants depends strictly on the type of the basin, its load, location, and the materials from which it is made and with which it has direct or indirect contact. The age of the water and the used water treatment technology also play a key role. Author's own research in this topic, has shown that the commonly used systems using classical filtration on beds preceded by the coagulation process are not able to fully stop the micropollutants occurring in the water. In addition, the disinfectants used to ensure the microbiological safety of water contribute to the generation of a large number of micropollutants known as disinfection by-products. The accumulation of different types of contaminants, with proven biological activity, can be stopped by introducing additional processes into the water treatment technology or replacing some elements by in-depth treatment solutions. The literature indicated several processes that deserve attention in this regard, which include, among others: irradiation with UV radiators with different radiation spectrum, associated ozonation systems, pressure membrane processes and new generation filter beds. The adopted solution must guarantee the complete decomposition or retention of organic micropollutants. The implementation of processes supporting the treatment of swimming pool water meets the increasing requirements for water quality and allows to improve the comfort of pool users while extending the age of the water. However, the introduction of a new technological solution must ensure not only the improvement of water quality, but must also be economically justified.

MANAGEMENT OF PLUMBING IN SWIMMING POOLS AND GUIDELINES

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The Directive (EU) 2020/2184 on water intended for human consumption fixes criteria and parameters also for managing internal plumbing systems of priority buildings/premises. In fact, it is well known that water quality at the tap can be affected by the domestic distribution system. According to this principle, risk assessment and risk management should therefore also focus, inter alia, on the control of plumbing in sports centres, leisure facilities and swimming pools. The WHO notes that *Legionella* causes the highest health burden of all waterborne pathogens. It is transmitted by warm water systems through inhalation, for instance during showering, and its spread is therefore clearly linked to the domestic distribution systems. According to the directive, in order to reduce risks connected with the internal distribution systems, a series of controls and measures must be implemented. In particular, in relation to *Legionella*, effective control and management measures have to be proportionate to the risk and able to prevent possible outbreaks of the disease. Similarly, the directive requires that inspections and monitoring must also be carried out on lead in the internal water systems of old premises. In this context, the Italian National Institute of Health, in conjunction with the Ministry of Health, has drawn guidelines on assessment and management of risks associated with water safety in internal plumbing systems in priority and non-priority buildings. The guidelines provide policies, knowledge elements and operational tools especially for professionals interested in managing internal plumbing systems. Criteria and guidance provided could enable assessment, identification and control of potential sources of chemical and microbiological hazards, as well as the development of inspection or testing programmes for specific parameters, such as lead and *Legionella*. The complex plumbing systems of swimming facilities are also affected by internal contamination problems, especially when the facilities are old or have centralised water heating. For this reason, the implementation of appropriate operational procedures and controls based on risk assessment criteria can improve the adequacy and safety of the entire facility's water system to protect the health of users.

RESPIRATORY SYMPTOMS IN YOUNG ITALIAN COMPETITIVE SWIMMERS: A CROSS-SECTIONAL STUDY

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The present study aimed to investigate the prevalence of respiratory symptoms and the training factors possibly associated with them in a sample of young Italian competitive swimmers. A secondary objective was to explore the effects of the COVID-19 pandemic on the same sample by analyzing how the disease and the restriction measures affected training. A questionnaire elaborated ad hoc was used for collecting demographic and training information of competitive swimmers and to assess their respiratory symptoms not related with infectious diseases, if any. Cases of COVID-19, number of training days lost due to the disease or to the closure of swimming facilities, and possible alternative training adopted were also investigated. The questionnaire was administered to participants during the winter and summer 2021 training seasons. In total, 396 athletes took part in the study. In the winter subgroup (n=197), significant associations were found between training hours per session and nasal congestion/rhinorrhoea (OR=3.10; p=0.039) and cough (OR=3.48; p=0.015). Total training hours per week were significantly associated with nasal congestion/rhinorrhoea (OR=1.12; p=0.010). In the summer group (n=199), the same correlations were not found. Having an allergy significantly increased the risk of nasal congestion/rhinorrhea, while having asthma was significantly associated with coughing. The kind of environment (indoor or outdoor facilities) did not affect the studied symptoms either in summer or winter. Regarding the effects of pandemic, twenty-four (6.1%) participants were affected by COVID-19 and lost, on average, 32 training days for this. The closure of facilities determined an interruption in swimming training for about 18% of the participants. Many of these individuals continued their training, principally by doing home-based exercise, but reduced their weekly training time (-8 median hours/week). Besides, regularly adopted weekly training was positively associated with weekly training assumed during pandemic closure (OR=9.433, CI95%=1.644–54.137, p=0.012), suggesting that the previous level of engagement in sport can represent a predictor of exercise maintenance in challenging situations such as a pandemic. Training seems to be related with non-infective respiratory symptoms in competitive swimmers. Further investigations are needed to better understand the factors and the mechanisms involved in this phenomenon. In addition, devoted studies should be performed to identify personal, environmental, and social resources that helped competitive swimmers to counteract the negative effects of COVID-19 pandemic.

SWIMMING POOLS: THE LOGIC OF RISK ASSESSMENT AS A PREVENTIVE APPROACH FOR HEALTH AND SAFETY MANAGEMENT

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The primary objective of Healthcare is the protection of public health: an objective that can be pursued through an articulated number of plans and actions linked by the logic of risk assessment as a preventive approach for health and safety management of the world of swimming pools. The analysis first of all the dangers related to the reality of the swimming pools and after the evaluation and management of the derivable risks find in the supervision, for the Institutions, and in the self-control, for the managers of the swimming facilities, the tool through which to effectively materialize in the daily. For almost twenty years now, the institutions, at European level, have adopted an approach that looks first at the dangers and not at the risk, with the aim of identifying the correct working methods. In particular, from this point of view, the self-monitoring designed and implemented by the manager plays a fundamentally important role. Even with the aim of guaranteeing the health of the user in the pool, the manager must be left with full autonomy in organizing his own control system. However, this system must guarantee a technical-scientific methodology that ensures the effectiveness of the system itself and allows the achievement of the hygienic-sanitary requirements imposed by the law and contemplated in the new National Prevention Plan 2020-2025. Self-monitoring is a system aimed at guaranteeing the hygienic safety of swimming pool users, through the application of a combination of articulated actions aimed at preventing, reducing or eliminating potential dangers in the swimming pool environment. It is a method which, if systematically adopted, projects the swimming pool from a management point of view towards the Health and Prevention system.Self-monitoring essentially aims to:

1. the identification of all the dangers related to health and hygiene safety, potentially present in the swimming pool environment;
2. the prevention of the occurrence of such dangers through specific preventive measures and the definition of critical points or phases to keep under control;
3. the preparation of control and monitoring systems for these parameters or phases and interventions in the event of anomalies and non-compliance.

Self-monitoring must address the analysis of all the dangers that may occur in the swimming pool: both those deriving from the quality of the water for hygienic-sanitary protection, and the environmental ones for safety from accidents or events dangerous to health. The key element of the system is the preparation of control procedures in correspondence with the critical points, in order to highlight any anomalies and/or problems in real time before any danger occurs in the swimming pool environment. The systematization of the procedures also offers the advantage of affirming the professional quality of the manager since he is responsible for adopting a methodology that gives

credibility to the entire system, in relation to the pre-established objectives of hygienic-sanitary protection. In fact, the operating methods contained in the self-monitoring require you to operate with knowledge and awareness within the entire company process with particular attention to the state of the structures, technological systems, general and punctual hygienic-sanitary conditions. In order for the application and effectiveness of the procedures contained in the management plan to be guaranteed, they must be brought to the attention and must involve all the personnel in charge of the swimming pool itself. In recent years there has been a professional growth that can be considered achieved, when in step with the technical and legal adjustments, can boast complementarity with the Institutions for the purpose of Health.

Poster Session

WILL EARTH-TO-AIR HEAT EXCHANGERS FIND APPLICATION IN SWIMMING POOL HVAC SYSTEMS?

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HVAC = Heating Ventilation and Air Conditioning systems in swimming pool buildings are responsible for maintaining thermal comfort, Indoor Air Quality (IAQ) and protecting the building structure from the negative effects of water vapor. Due to the large number of people and intensive evaporation of water, ventilation systems are particularly important as well as energy-consuming in these buildings. Various types of solutions for these systems are currently in use: decentralized structures, waste heat recovery or heat pumps to meet the energy needs of pool facilities. Earth-to-air heat exchangers, on the other hand, are a device that provides pre-treatment of ventilation air: its cooling and dehumidification (in summer) or heating (in winter) thanks to the use of renewable energy accumulated in the ground. These devices are used rarely (or not at all) in swimming pool facilities. The poster presents the concepts and structures of earth-to-air heat exchangers and their potential to discuss their applicability in swimming pool facilities. The poster presents earth-to-air heat exchanger technology as a system that (i) protects air handling unit heat exchangers from frosting, (ii) dehumidifies and cools ventilation air in summer, (iii) preheats ventilation air in winter, and (iv) can reduce frosting of air heat pump evaporators and increase the annual average COP (for heating) and EER (for cooling). The graphs show the annual variation of ground temperature at different depths against a typical meteorological year, characteristic of the climate of Central Europe. Using previously developed computational models, the annual heat and cooling yields due to exchanger operation were presented quantitatively for sample input data. Finally, research questions were presented to inspire research into the feasibility of using earth-to-air heat exchangers in swimming pool facilities, which will quantitatively assess whether this technology will enable a reduction in energy consumption for heating, ventilation and cooling purposes, and thus reduce the cost of pool operation, as well as reduce the negative impact of the swimming pool on the environment by reducing the use of natural resources (energy resources).

LIFEGUARDS AND COVID-19 PANDEMIC: SAFETY AND TRAINING

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Introduction. On March, 2020, most swimming pools were forced to close in Italy due to COVID-19. The risks identified were not related to water transmission of the Sars-CoV-2 virus in adequately sanitized pools but with difficulty in managing physical distancing and with cleaning in external pool areas. The reopening of the indoor pool facilities has been allowed since June 2020 on the basis of guidelines produced by the National Institute of Health (ISS) and the Italian Swimming Federation (FIN).

Results and conclusions. In the period June-October 2020, several training courses for Lifeguards for a total of 66 participants with a total of training hours in water of 950 hours/ student were realized in The Metropolitan City of Rome. The conditions and methods of carrying out the activities have been respectful of the regulations suitably modified, in particular on the distance in the changing rooms and use of the masks. The water quality of the pools has always been in the parameters provided by the ISS guidelines and which have led to an increase in the minimum free chlorine concentration in the water from 0.7 to 1.0 mg/L. Students and lifeguards' trainers on the pool floor have worn the mask. Those are in the water have complied with the norm of 7 square meters per person and in each lane the number of students has been kept in maximum number of 5 making maintaining a minimum of one meter in the breaks of the activities. The activities of the course program established by the circular regulations of the Lifesaving Section of FIN. that involve exercises and simulations with a direct contact between the student/rescuer and student/figurante-unsafe were carried out using the dummies provided for in the lifesaving competition or by appropriately changing the techniques while maintaining a minimum distance of one meter between the heads of the students and in any case for a time less than 15 seconds. In the final stages of the training course, when students have shown that they have acquired suitable skills, are engaged in using the dragging or transport techniques normally used with the precaution of performing the exercise for short stretches and remaining in a condition of *"apnea"*. The adopted precautions in compliance with the rules laid down in the ISS and FIN guidelines have allowed activities to be carried out safely and the courses have not been outbreaks of the pandemic.

FOOTBATHS: THE WEAKEST LINK OF SWIMMING POOLS?

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Introduction. In December 2020, an Interregional Working Group with the participation of the Ministry of Health and the National Institute of Health was created to update the Agreement State-Regions and PP.AA of 16/01/2003 and Interregional Agreement of 16/12/2004 regarding quality health standards for Italian swimming pools.

Results. Within this framework, swimming pool footbaths play a fundamental role in hygiene by cleaning feet, potential vectors of fungi, viruses or bacteria which can be transmitted from individual to individual. Footbaths also ensure that bathers do not enter the pool with leaves, grass, etc. clinging to the feet. The footbath must be designed in such a way that bathers cannot avoid using it and that they have to put both feet in it. Thus it is imperative that it is at least 2.20m which is the equivalent distance of three steps, and is large enough to facilitate the complete cleaning of the wheels of a wheelchair for disabled bathers. Its width must no be less than 1.60m to allow two people in wheelchairs to pass each other. The footbath is supplied with chlorinated running water. A series of case studies on footbaths in swimming pools will be reported and discussed during the presentation.

CHARACTERIZATION OF WATER AND BIOFILM BACTERIAL COMMUNITY IN A WELLNESS CENTER: A PRELIMINARY 16S METAGENOMIC STUDY

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The humid-wet surfaces and warm-humid environments characterizing the swimming facilities and the wellness center's whirlpools represent excellent conditions for microbial survival. Gastrointestinal, ophthalmic, otolaryngeal, respiratory, and skin infections can be transmitted to users by contaminated pool water. Regulations require monitoring of pool water quality through the detection of bacterial indicators using cultural methods, but these do not always allow detection of all pathogenic microorganisms present. These limitations have been overcome by Next-Generation Sequencing (NGS) technologies, which allow the detection of culturable and non-culturable microorganisms. This study aims to characterize the entire microbial community in water and biofilm samples in a wellness center in Rome by 16S rRNA gene sequencing to assess potential exposure to waterborne human pathogens. Water (n: 2) and biofilm swabs (n: 3) samples were collected in duplicate from the whirlpool, footbath, and air handling unit. Nucleic acids were extracted and the V3-V4 hypervariable region of the 16S rRNA gene was amplified. Positive samples were sequenced with the NGS - Illumina MiSeq II platform and analysed with the QIIME 2 pipeline. Water samples from the air handling unit showed the highest biodiversity with Shannon's index (6.13), while footbath swab samples were characterized by a lower Shannon's index (4.22). The most frequently detected *phyla* were: *Actinobacteria* in indoor swimming pool swabs, *Proteobacteria* and *Firmicutes* in whirlpool swabs, *Proteobacteria* and *Cyanobacteria* in footbath water. Moreover, *Proteobacteria* were found in the footbath swab samples and in water samples from the air handling unit.The genera with the highest relative abundance were *Micrococcus* in indoor pool swabs (43.25%) and *Staphylococcus* in whirlpool swabs (23.06%). Opportunistic pathogenic species such as *Enterobacter, Brevundimonas, Mycobacterium, Legionella,* and *Pseudomonas* were detected below 2%, except for *Sphingomonas* and *Streptococcus,* both found below 5%. Species belonging to the *Micrococcus* genus commonly are found in a large variety of terrestrial and aquatic ecosystem. The skin of warm-blooded animals, including humans, is a main reservoir for *Micrococcus* strains that is not considered to be pathogen. However some species have occasionally been reported to cause various types of infections (pneumonia, bacteraemia, endocarditis, and septic arthritis). *Staphylococcus* species, widely spread in nature and

responsible for numerous diseases, are significant contaminants in swimming pools and other recreational waters. However, sequence analysis of the short-read 16S rRNA region does not allow definitive identification of pathogens at the species level, but still provides a broad overview of all bacterial genera, including pathogenic species responsible for waterborne infections; it could be, therefore, a valuable tool for evaluating the effectiveness of sanitization and disinfection treatments in recreational facilities.

WHAT CAN THE GLOBAL CHLORINE INDUSTRY DO TO IMPROVE LOCAL POOL AND SPA CHEMICAL SAFETY?

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Globally, chemical producers have committed to ethical frameworks that foster safe chemical management. These frameworks are voluntary initiatives, beyond legislative and regulatory compliance, that commit companies, chemical industry associations and their partners to foster the responsible management of chemicals by everyone along the product chain. Examples of this include the Responsible Care® initiative, launched in 1985, which has since been extended beyond chemicals manufacturing to other activities, including those associated with the safe use and handling of products. In recent global pool and spa chemical incidents, there is a recognized need to focus on the safe storage and handling of chemicals utilized for pool and spa disinfection. With the inspiration of Responsible Care®, and via their global group (the World Chlorine Council), manufacturers of some pool and spa chemicals based on chlorine have created and/or shared a series of free tools and ran global webinars, to raise awareness amongst pool and spa operators and their handling companies. These activities aim to encourage the safe transportation, storage and handling of pool and spa chemicals and are already leading to fruitful global collaborations. This poster describes some of these safety initiatives. It outlines several current pool chemical safety challenges as well as efforts to overcome them through effective communication to pool and spa operators, how to communicate on pool/spa chemical safety effectively and highlights the needs for the future of this critical interesting, but vital, topic.

SOLUTIONS FOR SUSTAINABLE RESOURCE USE IN AQUATIC FACILITIES – AN INTERNATIONAL PERSPECTIVE

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For decades, recreational facilities have been built with a focus on low initial investment rather than sustainable use of resources without consideration of ongoing operating cost. The recent energy crisis has dramatically increased operating cost for water and air treatment and operators are desperately looking for solutions. Also, climate change challenges force pool operators to reevaluate the use of resources used in to reduce their carbon foot print. However, any savings must not jeopardize indoor air quality, water quality, create unhealthy air for bathers and staff, nor create corrosion issues in the building. The main objective of the paper is to evaluate energy, chemical and water cost savings, and the effects on carbon foot print by different treatment options in existing aquatic facilities within German, Austrian, US and Albertan (Canada) standards and regulations. A comparison of regulatory requirements shows both potential positive and negative impact on the recirculation system design, system optimization opportunities and resulting operating cost in the various regions being compared. Our results indicate that effective removal of organic contamination minimizes DBPs in the filtrate. In addition, flow reductions may only be possible by either increasing the efficacy of the treatment process, by increasing dilution or by reducing organic load in order to maintain adequate water quality required by regulations. Off-gassing of volatile DBPs is substantially higher in pool facilities when attractions are in operation and during swim meets and training. Practical tests have highlighted that a number of key parameters need to be monitored in order to control air flow, dehumidification, fresh air intake and exhaust by air handling system in aquatic facilities. The water and air quality as well as a sustainable operation of aquatic facility is often determined by design and chosen characteristics, but also by limitations built into the facility during design/construction. In this context, the carbon footprint of different process steps and their impacts on the above are evaluated. In conclusion, both air and water quality need to be monitored to minimize energy consumption. Therefore, relevant quality parameters for the control of resources in air and water treatment are identified to generate savings in operating costs. Case studies highlight various water solutions that help to address the financial impact on aquatic facilities.

THE REVISION OF THE ITALIAN STANDARDS UNI 10637 FOR PUBLIC SWIMMING POOLS

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Regulatory framework. The Italian standard UNI 10637:2016 on Swimming pools - Requirements for circulation, filtration, disinfection and chemical treatment of pool water - provides a classification of swimming pools and specifies the requirements of design, construction and management of water treatment plants of the public swimming pool. The standard also provides information on tests and checks to ensure that the pool water quality is adequate for bathing.

Results and conclusions. The Italian standard UNI 10637:2016 is being revised and optimized by the UNI WG11 "Swimming" involving several authoritative Italian experts (e.g., Assopiscine, Italian National Institute of Health, etc.). The revision of UNI 10637 takes into account the relevant European Standards (e.g., UNI EN 15288-1 and 2 UNI EN 13451-xx; UNI EN 1069-1). The review integrates and improves the standards based on the experience gained in its application and will take into account:

- Technological updating.
  - New types of filters: ultrafiltration.
  - New recirculation pumps: variable frequency motors.
  - New technologies for disinfection: production of sodium hypochlorite from salt electrolysis in and off-line.
- New types of swimming pools (swimming pools in tourist-accommodation facilities, recreational pools equipped with whirlpools, fountains, etc.).
- Environmental impact.
  - Well-sized recirculation systems.
  - Reduction of pressure drops.
  - Filter efficiency.
  - Permanent magnet pumps and variable frequency.
  - Heat recovery from waste water.
- Energy saving.
- Water saving.

Use non-potable water but with chemical-physical and bacteriological characteristics suitable for use in the pool. Reduce the use of drinking water in the pool: use of filters that require less washing water or reduce the amount of daily renewal. Reuse the waste water and filter washing water for other purposes after appropriate treatment use as technological water Publication of UNI 10637:2016 revision is expected in the second half of 2023.

DESIGNING A SWIMMING POOL VENTILATION SYSTEM: THE INFLUENCE OF THE EVAPORATION RATE

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In order to design a swimming pool ventilation system as a sustainable system that works well in terms of providing thermal comfort to users and energy efficiency to ensure a healthy environment, many aspects need to be considered. While designers most often rely on formulas that determine water evaporation, the actual evaporation is different. Similarly, the design of air distribution is based on the designer's professional experience, combined with the standards and guidelines in the country in question. This is a safe approach in terms of removing moisture because it mostly overestimates the evaporation, but as a result, the size of the installation and, ultimately, the energy consumption of the ventilation system will be higher than necessary. The evaporation rate in indoor swimming pools is a result of both the ventilation design and the operation of the swimming pool. In order to design a properly functioning ventilation system for a swimming pool facility, a number of parameters must be considered: water area, set points of water and air temperature, number of people using the pool and their level of activity, the air distribution system and the type and number of water-splash-elements with levels of operation. Each parameter influences the evaporation rate and so the size of the air ducts as well as the future energy consumption of the facility. During a study, the calculated evaporation from different methods was compared with the actual evaporation on a laboratory scale and real swimming pool facilities. The impact of evaporation rates on the design of the ventilation system will be discussed in relation to the chosen method for determining evaporation. The different formulas used to calculate the evaporation rates for occupied and unoccupied swimming pools will be discussed as their impact on the size and energy consumption. The theoretical analyses will be complemented by *in situ* measurements of evaporation rates in several different swimming pool facilities, as well as standardized laboratory evaporation rate measurements. As a result of this analysis, formulas for the design of swimming pool ventilation will be recommended, along with an assessment of the impact of the choice of these formulas on the predicted energy consumption of the ventilation system.

PRE-SWIM HYGIENE: THE ROLE OF THE USERS' BEHAVIOUR ON POOL WATER QUALITY

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Pre-swim hygiene is a set of behaviors that should lead to limiting the introduction of organic substances, such as sweat, urine, as well as personal hygiene products and cosmetics, into the pool water. As a result of the reaction between organic substances (TOC, DOC) introduced by swimming pool users and chlorine compounds present in the pool water as a disinfectant, by-products of swimming pool water disinfection are formed: chloramines and THM. Research on swimming pool water parameters and users' behavior in terms of preswim hygiene are conducted in various countries around the world, e.g.: in the Netherlands, Italy, Poland, Canada, and Ethiopia. The poster will present the results of this research, which will show how difficult it is to normalize the behavior of users in terms of taking a shower before entering the pool. The results of an experiment carried out in Poland, in which the concentration of Dissolved Organic Carbon (DOC) and the concentration of THM were measured, will be presented in detail. In the chloroform facility where the concentration was above the permissible values -40.7±9.68 μg/l, an experiment was carried out to assess the impact of obligatory showering before entering the swimming pool on water quality. During the experiment, the values of water parameters have improved; concentrations of DOC, THM, and chloroform decreased. The chloroform concentration decreased to 29.4±3.8 μg/l, THM concentration to 31.3±3.9 μg/l, and the DOC concentration to 6.09±0.05 mg/l. The control results of the parameters tested were also carried out after the end of the main experiment. The concentrations of DOC and THM were worsened. The results of the experiment covered a short period of time because conducting such research in existing facilities is extremely difficult. The results presented indicate that it is necessary to cooperate between scientists and technicians to develop solutions that will make pre-swim hygiene common.

THE NEW DIN 19643, STANDARD FOR QUALITY AND TREATMENT OF SWIMMING POOL WATER IN GERMANY

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The standard DIN 19643 reflects the generally accepted rules of technology for the treatment of swimming pool water in Germany. As an example, the standard also finds wide acceptance in a range of European countries. In the absence of a comprehensive legal framework or respective binding legislation in Germany, the series of respective standards is of great importance with regard to water quality and hygiene as well as the construction and operation of swimming pools and its water treatment plants. The currently valid series of the standard DIN 19643 date from 2012. According to the requirements of the German Institute for Standardization (DIN), standards are to be reviewed latest every 5 years to ensure they are up to date and revised if necessary. Since also the state of the art had evolved in the meantime, a revision of DIN 19643 was initiated in 2017 and completed in fall of 2022. Moreover, a new part 5, describing a process involving bromine, generated by ozonation of bromides as a disinfectant, was published in 2021. In order to involve all interested parties, standards are processed in an appeal and consensus procedure. Therefore, the standards were submitted to the technical community in May 2022 with a public enquiry period of 5 months. After this period, objections were dealt with until November 2022 and publication can be expected in spring of the year 2023. In addition to many minor changes and adjustments, the following topics were the main focus of the novelized standard:

- revision and grouping of the chemical-physical water parameters;
- tables for evaluation and derivation of measures in case of detection of legionella in pool water and filtrate;
- dimensioning of the flocculation process;
- addition of filtering materials made of glass;
- rinsing of fixed bed filters;
- definition of a chemical barrier for therapy pools;
- adaptation of the conditions for the use of ozone as a microbiological barrier;
- requirements for disinfectants in the light of the addition of bromine, generated by ozonation of bromides as a permissible disinfectant.

Additionally, the guidelines of the German Swimming Pool Association (Deutsche Gesellschaft für das Badewesen) provide more details on special applications, such as suctions, pool operation, pool hydraulics and the like. This presentation aims at giving an insight at German regulations and guidelines in general and at the DIN 19643 in particular, within the legal framework (Infection Protection Act).

THE NEW EUROPEAN STANDARD EN 17818 FOR *IN SITU* GENERATION OF CHLORINE PRODUCTS BY SALT ELECTROLYSIS

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To ensure the hygiene of swimming pool water, disinfectants (mainly chlorine products, but also ozone or bromine or combinations of the aforementioned) have been used for decades, also required by national legal requirements on infection protection. Since the process involves a killing (biocidal) effect, the disinfectants used are accordingly biocides. As such, they are subject to the EU Biocidal Product Regulation 528/2012 (BPR) and need approval and authorization as active substances and biocidal products. The regulation provides for approval requirements not only for disinfectants purchased ready-made, but also for active substances produced on site, so-called *in situ*, and/or their precursors, e.g., sodium chloride. The entry into force of EU Biocide Regulation 528/2012 has caused turmoil and even distress in all sectors in which disinfection with various disinfectants, including chlorine, is used. Disinfection processes and substances that have been used and tested for decades have been and are being put to test in terms of effectiveness as well as ecological and human toxicity. Thus, the treatment of swimming pool water with the disinfectants which use chlorine (both produced on site and supplied in ready-made containers), ozone as well as ozone-bromine, is also affected. Biocide generation devices are per se not subject of the BPR, but the approval process must also take into account the production process as such, because there are, for example, countless electrolysis devices of different types, with different processes and therefore also different products with different modes of action and different toxicological hazard potential, as far as the generation of possible synthesis and disinfection by-products – such as chlorate and/or perchlorate and others – is concerned. For this purpose, EN 17818 – In-situ generation of biocides - Active chlorine, generated from sodium chloride by electrolysis – was drawn up as a European standard with minimum requirements for devices and equipment used for the disinfection of water and/or water-contacting surfaces by means of on-site electrochemical processes. EN 17818 is thus intended to support manufacturers, operators, and competent authorities in the context of the approval and authorization procedures according to BPR and can be cited as a generally accepted rule of technology. The author is Convenor of CEN TC 164 / WG 16, which elaborated EN 17818 and will give deep insights on the standard, the legal background, and the detailed electrolysis processes.

MANAGEMENT OF CHEMICAL-BACTERIOLOGICAL DISCREPANCIES IN SWIMMING POOLS IN THE EMILIA-ROMAGNA REGION

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In Italy the legislation act on swimming pools is the State-Regions Agreement No. 1605 of 16/1/2003 "Sanitary and Hygienic Aspects for the Construction, Maintenance and Supervision of Swimming Pools for Swimming Use". This Agreement has been implemented by all Regions with their own legislative provisions. On December 2004 the Conference of Presidents of the Regions and PP.AA. of Trento and Bolzano has ratified the Interregional Agreement on the "Interregional Discipline of Swimming Pools" to define further specifications and aspects of regional competence. Emilia-Romagna Region (RER), considering its legislative autonomy, issued Resolution No. 1092 of 18/7/2005 Regional Regulations: “Sanitary and hygienic aspects for the construction, maintenance and supervision of swimming pools for natatorial use” which does not consider sanctions in cases of non-compliance. RER would improve supervisory activities in swimming pools to overcome critical management and hygienic/sanitary aspects considering all the new businesses activities raised over the years and the absence of a clear regulatory framework regarding control activities. During their supervisory activities reported in 2018, the Public Health Departments on the regional territory carried out 2.695 sampling for chemical parameters and 2.522 sampling for microbiological parameters out of a total of 1.943 pools. The COVID-19 pandemic and the recent severe energy crisis have led to serious repercussions on the productive sectors of the national economy, also for operators and owners of pools. Furthermore, on the end of June 2022, RER requested the national state of emergency due to the severe water crisis to face the environmental, agricultural and economic consequences and issues an ordinance with first related indications. The public health measures and restrictions connected to the pandemic, the incurring of water shortage and the increase in operating energy costs have not facilitated virtuous management of swimming and recreational aquatic environments, which has emerged through supervisory activities: the analytical discrepancies resulted sometimes in the temporary closure of facilities until the restoration of the parameters to protect the bathers’ health. The Interregional Agreement is a political-institutional act that commits the Presidents of the Regions to develop regional disciplines based on the contents of the Agreement signed on 16/1/2003 but some aspects are left to regional autonomy, in order to develop shared definitions (structural and management requirements, controls, bathers...). RER and a group of experts from other Italian Regions proposed a new technical framework to regulate swimming pools activities considering all possible cases and identifying adequate regulatory tools for supervisory activities.

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