ISTITUTO SUPERIORE DI SANITÀ

Fifth International Conference Swimming Pool & Spa

Istituto Superiore di Sanità
and Università di Roma Foro Italico
Rome, April 9-12, 2013

ABSTRACT BOOK

Edited by
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The Conference is focused on Health, Safety and Quality of recreational waters. It represents a great opportunity not only for social development and health promotion, but also for basic and applied research. Many aspects related to swimming pools and Spas have been taken into consideration and they can represent a cultural, scientific and useful updating in activities of control and prevention, and in protection of the bather health and operating staff. Primary aim of the Conference has been to provide a scientific forum for presenting novel approaches and recent results in health promotion by recreational waters; safety and quality by advanced monitoring and treatment technologies; chemical and microbiological risks; regulation guidelines. The in course of preparation WHO guidelines have also been introduced with the updated state of knowledge regarding all these topics.

Key words: Swimming pools, Spa, Recreational water quality, Water treatments, Risk assessment

Istituto Superiore di Sanità
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A cura di Emanuele Ferretti, Guglielmina Fantuzzi, Vincenzo Romano Spica, Sergio Caroli e Lucia Bonadonna.
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La Conferenza è centrata sugli aspetti relativi alla Salute, Sicurezza e Qualità delle acque ad uso ricreativo. Essa rappresenta una grande opportunità non solo per lo sviluppo sociale e la promozione della salute, ma anche per la ricerca di base e applicata. Sono stati presi in considerazione molti aspetti legati alle piscine e alle Spa che possono rappresentare un utile aggiornamento culturale e scientifico nelle attività di controllo e prevenzione, e nella tutela della salute dei bagnanti e del personale operativo. Obiettivo primario della Conferenza è stato quello di fornire un forum scientifico per presentare nuovi approcci e i risultati più recenti per la promozione della salute associata alle acque ad uso ricreativo; inoltre, sono stati considerati gli aspetti riguardanti sicurezza e qualità dell'acqua mediante tecnologie di monitoraggio e di trattamento avanzate, rischi chimici e microbiologici, linee guida di regolamentazione. È stato anche presentato l'avanzamento dei lavori sulle linee guida dell'OMS, in corso di preparazione, e lo stato dell'arte aggiornato.

Parole chiave: Piscine, Spa, Qualità delle acque ad uso ricreativo, Trattamenti delle acque, Valutazione del rischio

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PROGRAM

Tuesday April, 9

9.15 Participants registration

15.00 Opening ceremony - Welcome address
ISS (Italian Institute of Health),
University of Rome Foro Italico,
University of Modena and Reggio Emilia,
FINA (Federation Internationale de Natation)

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Enkhtsetseg S.

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ICSPS Recognition Awards

18.00 Welcome cocktail

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9.20 *A review on microbiological issues related to swimming pools*
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9.40 *A review on monitoring and disinfection issues*
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10.00 *The health promotion and social benefits of recreational waters*
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10.20 *Conclusions and new perspectives for the Conference*
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9.25 *New regulations for swimming pools and Spas in the Netherlands*
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9.35 *A new legal regulation for the quality of bathing water in Austria*
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9.45 *A UK code of practice for public swimming pools*
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10.15 Discussion

10.30 Coffee break

6th ICSPS election

Abstract Prizes

NOTES FOR THE READER

This volume gathers all the contributions presented at the Fifth International Conference Swimming Pool & Spa. For an easy consultation the abstracts, divided into oral and poster presentations, are listed in the order of the program, ranked in sessions from I to IX.

The poster abstracts are listed in the session VII and are numbered with a code including a progressive number and the Roman number referring to the session which the poster belongs to (*e.g.* 1-II, Poster 1 belonging to session II).

At the end of the volume, the authors' index is provided for the reader's convenience.

Session I

Introduction

Chairperson

M. Kádár, L. Bonadonna

A REVIEW OF MICROBIOLOGICAL ISSUES RELATED TO SWIMMING POOLS

Mavridou A.
Technological Educational Institution, Department of Medical Laboratories, Athens, Greece

Waterborne diseases can be acquired through recreational waters, manmade environments being responsible for 90% of such outbreaks. A number of national assessments show that in many countries a relatively small proportion of pool facilities meet national regulations for water microbiological quality. In this review, information regarding microbial risks related to swimming pools and spas was collected from a) the four European Swimming Pool and Spa Conferences, b) the international literature with emphasis on review papers, c) data published by national and international authorities and organizations, and d) an overview of pool and spa regulations in Mediterranean countries commissioned by the WHO. With regard to a) above, the review search of the four Pool and Spa Conferences' scientific programs indicates that 70% of the papers deal with *Cryptosporidium spp* detection and control. Notably, as regards b), publications on *Cryptosporidium spp* detection and control have increased over time. The literature review revealed that in many among the recently investigated outbreaks *Cryptosporidium spp* was the implicated pathogen. Furthermore, noroviruses are the largest cause of the viral outbreaks (45%). As regards c), adverse health outcomes of water recreation are illustrated by surveillance schemes (CDC, ECDC, EWGLI). According to CDC data, 292 outbreaks with 23,800 cases were attributed to treated recreational facilities in the USA, with *Cryptosporidium spp* being the causative agent of 74.1% of AGI outbreaks (1999-2008). As regards d), 20 out of 22 countries answered the relevant questionnaire. Provisions regarding water microbial quality are included in the regulations of 16/20 countries for swimming pools and in all 11 regulations for spas. A literature review of pool microbial quality in these countries showed that, unlike in other parts of the world, *Pseudomonas spp*, MNTs and fungi are the predominant pathogens. Of course, it is not possible to control all swimming pools for opportunistic pathogens. Nevertheless, in one study bacteria (*Pseudomonas spp, Aeromonas hydrophila*, *Moraxella spp*, *Stenotrophomonas maltophilia*) along with fungal species *(Aspergillus nidulans, Acremonium Trichoderma, Penicillium spinulosum)*, which are considered as opportunistic, have been isolated from pool water samples. Research to establish a list of opportunistic pathogens common in pool waters may be a useful direction for forthcoming studies so as to focus attention on additional sanitary measures required in pools used by specific groups of users.

A REVIEW ON MONITORING AND DISINFECTION ISSUES

Erdinger L.
University of Heidelberg, Department for Infectious Diseases, Microbiology and Hygiene, Environmental Laboratory, Heidelberg, Germany

In contrast to drinking water, swimming pool water is subjected to permanent contamination. Only adequate water preparation and disinfection measures will allow economic operation. Water preparation in swimming pools may be performed using diverse technological steps including sand filtration, filtration by activated carbon, by precoated filters, by nano- and/or ultrafiltration, by use of coagulation using iron or alumina salts, and many other techniques. However, the aims of these water preparation steps are generally not well defined, if at all. Up to now, in most countries only parameters for contaminations by microorganisms are standardized taking into account that pool water needs to be disinfected, usually by chlorine gas; in addition, hypochlorite solution is used frequently. The amount of free chlorine necessary for safe pool water disinfection is difficult to define, it varies widely between different countries and may be connected to prevailing water treatment technologies. For example, whilst CDC recommends a minimum of 1 mg/L and suggests a limit of 3 mg/L, German regulations suggest concentrations between 0.3 and 0.6 mg/L in regular pools. Next to chlorine, other disinfectants play a minor role (f.e. chlorine releasing compounds like chlorinated isocyanurates; potassiummonoperoxosulfate, polyhexamethylene biguanide or disinfection systems based on several compounds with additive effects). However, control of these compounds or disinfection systems is challenging and not feasible on site at all, and micobiological analysis of the water may be impaired because no adequate neutralizers for these disinfectants are available. Contaminations in swimming pools consist of inorganic species, organic compounds and microorganisms brought in by the bathers. Measurement of contaminations, their residues, and their transformation products is difficult. Frequently COD (chemical oxygen demand) is used to describe water quality with special regard to organics. The meaning of water filtration, however, is the elimination of organics from the water. Therefore, reduction of COD may be a meaningful parameter for the definition of the filtration efficiency. Most Disinfection-by-products (DBP) will build up whenever organics meet reactive chemical compounds. However, depending on the quality and the amount of precursors as a function of water treatment employed, their composition may vary widely. Most DBPs identified so far are chlorinated compounds, trihalomethanes (THM) and chlorinated amines being the most important. Therefore, regular analysis of main DBPs should be included in every monitoring program. Finally, chlorate should be mentioned as an important monitoring parameter: chlorate concentrations may reach very high concentrations if outdated hypochlorite solution is used for disinfection.

THE HEALTH PROMOTION AND SOCIAL BENEFITS OF RECREATIONAL WATERS

Lachocki T.M.
National Swimming Pool Foundation®, Colorado Springs, CO, USA

Trends in the U.S. are well documented and may provide insight to other modern societies. As society shifts to a technology age, physical inactivity in the U.S. is decreasing. In addition, the average age of the population is increasing. As a result, obesity rates continue to increase and are not likely to stabilize based on growing obesity rates among children. Approximately 10% ($ 147 billion) of total healthcare cost in the U.S. is due to obesity-related illness. Healthcare is likely to suffer as a greater percentage of the population faces long-term chronic illness. As a result, government and industry will invest heavily to encourage more physical activity and better diet. For obese, inactive, and older people, aquatic immersion and activity are ideal forms of exercise yielding unique health and social benefits. Unfortunately, about one out of three to two out of three Americans fear deep water or report an inability to swim. As a result, many resist the opportunity to engage in aquatic activity even though “swimming for exercise” is a leading aspirational activity. Thus, leaders in the health-focused aquatic field must continue to research, document and disseminate aquatic health benefit research to influence more people to become confident, competent, and engaged in aquatic activity.

CONCLUSIONS AND NEW PERSPECTIVES FOR THE CONFERENCE

Kádár M.
National Institute of Environmental Health, Budapest, Hungary

Bathing in waters exposed to direct or indirect microbiological contamination from others and to the side effects caused by protective measures against it, too is an unavoidable source of hazards. They should be considered in the context of the of the bather/service-provider/regulator-supervisor triad in order to not only avoid the health risks but also other disorders as far as possible. The aim of our proceeding may not only be to quantitatively assess the microbial and other health risks that the bathers may be exposed to, but to reveal the interrelation of the passive occurrences and active moves by any of them, and to try and show the way to a common *modus vivendi* for the best possible benefit of all participants at the lowest possible price both in terms of economy and of social interferences. In order to arrive at a sensible result, all major events, technical, managerial and official interventions need to be rated and weighed in a complex way by uncovering their interactions and the harmful effects resulting from both the neglect and the exaggeration of them. Without going into the deeper scientific details, we have to review the social and health benefits, the categories of health risks and the actions and efforts or the lack of them made by the participants of the pools and spa scene. We could also try to call the attention to the dark areas in the overall knowledge and regulation of the scene and present proposals how to proceed in a harmonic way with the informed co-operation of the above mentioned participants. We need to look into issues of the skill and conscience of the service providers of all segments of the life-cycle of a pool and spa establishment, of the role and responsibility of the bathers as both the main sources and the victims of the health risks and of the sound approach to the evidence-based regulation and supervision of them.

Session II

Chemical risk in air and water

Chairperson

V. de Matos Beleza, G. Aggazzotti

TRICHLORAMINE INDUCED INHALATION TOXICITY *IN VITRO*

Junek R., Aust C., Grummt T.
Federal Environment Agency (UBA), Bad Elster, Germany

A typical and well discussed disinfection by-product in the case of swimming pool disinfection is Trichloramine (TCA). It is generated in the presence of free chlorine and small nitrogen containing molecules like urea. In comparison to mono- and dichloramine, it shows a 286 to 966 times higher volatility. This is one reason, why TCA is responsible for the typical smell of indoor swimming pools. As TCA is also known to be a very reactive gas, the question has emerged, which harmful potential it holds at which concentrations to swimmers and bathers. This study investigates the mode of action of TCA and its possible role as an asthma inducing compound. The results can also be one step forward to clarify, whether the increasing number of (childhood) asthma is connected to visits of chlorinated pools in the early childhood or not. The alveolar epithelial lung cell line A549 is treated in an air-liquid exposure system. To carry out the inhalation toxicity study *in vitro* for TCA we set up a test protocol, which places special emphasis on the highly metal corrosive and instable nature of TCA. First of all the material applied has to be inert for TCA. Secondly the TCA has to be generated in the laboratory shortly before and during the 2h the cell culture is exposed to it. The cell number was determined 4h TCA post exposure. Samples of the culture medium taken at the same time point were analyzed for early signs of inflammation (*e.g.* Interleukin(IL)-8) possibly leading to asthma. At high TCA concentrations with and without repeated exposure of the cell culture significant cell death was seen. Due to the cell damage the release of IL-8 was significantly reduced in these cases compared to the controls. At lower TCA concentrations and with repeated treatment the cell number was not reduced, but the IL-8 level was augmented compared to the exposure with synthetic air. These findings support the necessity to keep attention on TCA concentrations in the air of indoor swimming pools as a precautionary measure.

MONITORING OF HALOGENATED COMPOUNDS IN INDOOR SEAWATER SWIMMING POOLS TREATED WITH CHLORINE

Boudenne J.-L., Parinet J., Coulomb B.
Aix-Marseille Université-CNRS, Laboratoire Chimie de l'Environnement (FRE3416), Equipe Développements Métrologiques et Chimie des Milieux, Marseille, France

The disinfection is an essential and necessary stage to protect swimmers against infection by microbiological pathogens. However, the reaction between chlorine and organic matter (natural or anthropogenic) present in the water may lead to the formation of by-products that could be harmful for human being. More than of 100 disinfection by-products have been identified to date in swimming pools, the two most important families being the Trihalomethanes (THMs) and the Haloacetic Acids (HAAs). Despite THMs and HAAs are well known since their discovery in 1970's, these compounds continue to be the subject of many researches due to their implication in various pathologies. The French legislation imposes a value of residual of free chlorine ranging from 0.4 to 1.4 mg/L Cl_2 in the case of basins disinfected by bleach or chlorine gas, or an amount of at least 2 mg/L Cl_2 when stabilized with isocyanuric acid. In all the cases, the concentration of combined chlorine should not be superior to 0.6 mg/L Cl_2. On the other hand, there is no rule currently concerning THMs and HAAs contents in the basins supplied with seawater (excepted in the case of water treated by a UV-dechloraminator). Moreover, the current legislation does not take into account the specificities of these atypical basins like the elevated temperatures of water (30°C to 40°C), strong frequentation, and water's ionic composition rich in bromide ions. However, the addition of chlorine into a water rich in bromide ions conducts to the formation of hypobromous acid (HOBr), which is more reactive with organic matter than hypochlorous acid (HOCl). That implies a significant raise of brominated and mixed (brominated and chlorinated) by-products, usually found in the "classical" swimming pools feeded with tap water. Due to the dangerousness of brominated-THMs and HAAs for human being (more carcinogen than chlorinated-THMs and HAAs) and the absence of legislation concerning these compounds into seawater swimming pools, it appeared essential in a first time to better know the range of concentrations that we can find in these atypical basins to be able to assess the health risks and finally to propose realistic standard concentrations. The THM and HAA concentrations in air and in waters have been measured by GC/ECD and GC/MS in several establishments for a total of 8 indoor basins during a two years' survey. The correlations between DBP and other environmental factors such as Total Organic Carbon (TOC), pH, Temperature (T), free residual Chlorine (Cl_f), UV_{254}, chloride and bromide concentrations, Instantaneous Maximum Frequentation (IMF) and Daily Frequentation (DF) have been examined. The range of total THM concentration varies between 60 and 1300 µg/L and between 200 and 2,500 µg/L for the total HAA. In air, amount of THM may reach up to 1,000 µg/m^3. Among THMs or HAAs, prevalent species are the brominated ones such as bromoform, monobromoacetic acid, dibromoacetic acid and tribromoacetic acid. Iodinated compounds have also been investigated but their levels in water have never exceeded their detection limits (below 1.5 µg/L).

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IMPACT OF OPERATION PARAMETERS AND CARBON SURFACE OXIDATION ON MONOCHLORAMINE DEGRADATION BY GRANULAR ACTIVATED CARBON FILTRATION

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Chloramines, in particular Monochloramine (MCA), that are present in Swimming Pool Water (SPW) are formed by the reaction of urea or NH_4^+ with free chlorine. These substances are introduced to the SPW by the bathers. MCA is known to be a relevant educt for the formation of cancerogenic N-Nitrosodimethylamine which was recently found in swimming pool waters. In order to reduce chloramines, Granular or Powdered Activated Carbon (GAC or PAC) is used. The main mechanism for MCA removal by GAC/PAC treatment is not adsorption but a surface reaction, where MCA is degraded by a reaction with active sites on the carbon. In this reaction, MCA is degraded to N_2 or NH_4^+ while the active sites on the carbon surface are oxidised. Summarising the state of knowledge about MCA removal at GAC fixed bed filters, it can be emphasised that diffusional mass transport (extraparticle or intraparticle diffusion) is the main factor influencing the overall reaction rate. The intrinsic chemical reaction of MCA to NH_4^+ or N_2 is assumed to be very fast. However, no study has systematically evaluated the influence of operational parameters like particle size, flow rate or temperature, which are known to influence the diffusional mass transport and thus the overall MCA degradation at GAC. Consequently the aim of this study was to show and explain these influences. The results should lead to a better understanding of the limiting mechanisms on the heterogeneous reaction of MCA with the carbon. Based on these results it will be possible to design GAC-filters for SPW treatment taking advantage of faster MCA removal rates for specific operation parameters. Furthermore, in order to respect ageing of the carbon by formation of surface oxides was, the experiments were performed for fresh and artificially aged (oxidised) carbons. The reaction rate constant of the overall reaction was experimentally evaluated using a bench scale GAC-filter. It was shown that the ratio of molecules of NH_4^+ formed per mole of MCA degraded was ~0.75. Thus, most of the degraded MCA-N remains in the pool water cycle in form of NH_4^+-N, which again will form MCA in the pool by renewed reaction with free chlorine. Just 25% of the degraded MCA-N were removed after GAC-filtration as gaseous N_2-N. No dependence of the reaction rate constant from the filter velocity was shown. Thus film diffusion is not relevant for the MCA degradation reaction. Furthermore, the carbon raw material did not significantly influence the MCA-GAC reaction. In contrast, the mean particle diameter of a GAC filter bed had a significant influence on the reaction rate. Down to a minimum particle diameter of 0.3 mm, the reaction rate constant increased with decreasing particle diameter. For particle diameters smaller than 0.3 mm, the reaction rate remained on a constant level although the particle diameter was decreased. In this case it is supposed that the total internal surface is accessible for the MCA degradation reaction without extraparticle and intraparticle mass transport limitation. The MCA-GAC reaction was strongly temperature dependent. In general it could be summarized that: 1) the reaction rate constant increases with increasing temperature and 2) the reaction rate decreases with increasing oxidation of the carbon surface.

UV-INDUCED FREE-RADICAL REACTIONS IN CHLORINATED POOLWATER

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UV irradiation is routinely being used to reduce the level of bound chlorine in chlorinated poolwater, and hence the level of trichloramine in the air above the water. In 2006, Cassan *et al.* amplified the awareness about the increased risk of formation of undesirable chlorinated by-products in the poolwater when using this technology. These by-products are produced by the attack of chlorine radicals on organic precursors present. The precursors can be introduced via swimmers as well as through the makeup water. The chlorine radicals are generated by the illumination of hypochlorite/hypochloric acid with UVC. At the same time, however, hydroxyl radicals are generated. Hydroxyl radicals are well-known powerful oxidants for organic species. In principle, therefor, chlorinated by-products can be broken down by OH radicals at the same time as they are produced by chlorine radicals. In order to be able to predict the potential level of chlorinated by-products in pool water, the relative kinetics of their formation and their breakdown by these free-radical reactions must be known. To this end, laboratory experiments have been carried out with compositions that are relevant in pool water. Both medium-pressure lamps and low-pressure lamps have been used in the experiments. The model precursors used were humic acids and a Body Fluid Analogue. As the UV-dose is an important variable, a simple model has been made to calculate the UV-dose received by pool water during its residence time in a pool with practical UV irradiation. Combining the model calculations with the free-radical kinetics obtained from laboratory experiments gives good insight in the potential risk of formation of chlorinated by-products in practical situations.

EFFECT OF PH ON DBP FORMATION

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The regulation of DBPs has been focused on Trihalomethanes (THMs) and chloramines, which are easy to measure. Recent research has shown that other chlorinated molecules like Haloacetic Acids (HAAs) and Haloacetonitriles (HANs) are more toxicologically relevant. A Danish full scale study experimentally operated a swimming pool at lower than legally allowed pH and chlorine levels (pH 6.7 and 0.4 mg-Cl_2 *versus* pH 7.3 and 1.5 mg-Cl_2; the legal lower limits are pH 7.0 and 1.0 mg-Cl_2) and found a decrease in THM and chloramine concentrations while microbiological quality was retained. Based on this it has been suggested to allow lower pH and chlorine levels in Danish public swimming pools. In order to investigate the effect of pH on the formation of other DBPs than THMs, two series of laboratory experiments with simulated bather load or particle at intervals of 0.5 in the range pH 6.0-8.0 in the first experiments and at intervals of 0.1/0.2 in the range pH 6.5-7.5 in the second series of experiments. Chlorine concentrations were either kept constant or changed to retain the same active chlorine (hypochlorous acid) concentration. Laboratory batch experiments were performed with synthetic body fluid analogue or particles collected from a filter in a public swimming pool (1 mg/L TOC) and initial chlorine doses of 35 mg/L or 10 mg/L for 24 hour for the trichloramine and 48 hours for the investigation of formation of THMs, HAAs and HANs. As expected, a pH dependency of the formation of all DBPs was observed. The first experiments showed severe increase in formation of HANs and trichloramine at pH 6.5 and lower compared to pH 7.0 and higher. Based on calculations of predicted cyto- and genotoxicity from the concentrations of DBPs, the lower pH values are indicated to produce less healthy swimming pool waters. Of the investigated DBPs, HANs contributed most to the toxicity. In the second series of experiments it was found that formation of THM increased at pH higher than 7.2. The formation of HANs increased at pH under 6.8 in the experiment with 35 mg/L chlorine while the formation already increased at pH 7.0 when the initial chlorine dose was 10 mg/L. The formation of trichloramine was low at high pH and an increase was observed at pH below 7.0. When adding more chlorine (10 *versus* 35 mg-Cl_2/L) the formation of THM and trichloramine increased while the formation of HANs decreased with increasing chlorine concentration. From the investigated DBPs and selected experimental conditions, an optimal range for pH with low by-product formation was identified as pH 7.0-7.2. In a bit broader range of pH (pH 6.8-7.5), the effect of pH on the formation of by-products found to be minimal compare to other factors which is expected to affect the DBP formation in the swimming pool. The Danish Nature Agency and Danish Health and Medicines Authority has taken this results together with exiting literature as the background for changing the lower limit of pH in swimming pools to 6.8. The new regulation of swimming pools became effective in the summer of 2012 (Danish statuary order no. 623 of 13/06/2012).

OCCURRENCE AND FATE OF TRACE CHEMICALS IN SWIMMING POOLS

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Concerns arising over the presence of chemical contaminants in swimming pools have been growing as they may cause adverse health effects to swimmers. To date, majority of the studies have concentrated on identifying the presence of DBPs in swimming pools and simulated laboratory experiments have also been carried out to study the chlorination reactions. However, other emerging pollutants such as Pharmaceuticals and Personal Care Products (PPCPs) and Endocrine Disrupting Chemicals (EDCs) have not been well studied in swimming pools. These chemicals may be present in pool water through contamination from pool users themselves (body fluids, lotions, cosmetics, etc.) or from the source water used where trace chemicals may already be present. Swimming pools at two different locations in Sydney, Australia were analysed for 67 different types of trace organic chemical contaminants, which includes PPCPs, pesticides, xenoestrogens, nitrosamines, and steroidal hormones. Samples from different types of pools were collected and analysed. This will provide important information regarding the fate of trace chemicals aside from DBPs in different types of swimming pool water. Isotope dilution Liquid Chromatography tandem Mass Spectrometry (LC-MS/MS) was used to analyse triplicate samples of each swimming pool for PPCPs, pesticides and xenoestrogens. A total of 50 compounds were analysed in pool water which included 39 compounds of PPCPs, 10 pesticides and 1 xenoestrogen. The same samples were also analysed for steroidal hormones which consisted of 7 estrogens and 5 androgens using gas chromatography tandem mass spectrometry (GC-MS/MS). In addition, a separate triplicate sample set was collected and analysed for nitrosamines using GC-MS/MS. Swimming pool water was analysed for 8 different N-nitrosamines compounds. This study gives insight into the presence and concentrations of trace organic chemicals in swimming pools in Sydney, Australia.

Session III

Microbial Risk

Chairperson

R. Sommer, G. Liguori

CRYPTOSPORIDIUM REDUCTION AND OUTBREAK RISK: INTELLIGENTLY BALANCING FILTRATION, DISINFECTION, AND RECIRCULATION SUBSYSTEM EFFICIENCIES

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Waterborne disease outbreaks associated with swimming pools are a significant problem worldwide. In particular, the chlorine-resistant human pathogen, *Cryptosporidium*, appears to be the most problematic. Since the normal free chlorine residual level in pools can take a week or longer to achieve 3-log (99.9%) inactivation of Crypto, many regulators and designers are trying to improve the capabilities of pools to either remove (via filtration) or inactivate (via supplemental disinfection) *Cryptosporidium* oocysts to decrease viable pathogen concentrations as well as overall exposure to pathogens for swimmers. While common sand filters have been shown to remove less than 50% of Crypto from the water passing through the filter, there are more efficient filtration options as well as supplemental disinfection systems (like UV) that can produce overall reductions in viable pathogen concentration in excess of 3-log (or even 6-log). This presentation will include actual performance data from a wide range of filtration options at removing a Cypto-sized surrogate particle (i.e., microspheres of the same size, shape, density, and zeta potential of Crypto oocysts in pool water). Filtration alternatives will include ceramic media, charged zeolites, precoat media, and physicochemical treatment prior to sand filtration. Next, the efficiency of pool recirculation systems at returning water to the filter/supplemental disinfection systems for treatment will be discussed. Then, mathematical modelling results will be presented to describe overall system performance when filtration, disinfection, and recirculation system efficiencies are all combined. The results will show how optimizing a single subsystem of the model will produce only limited improvements in overall system performance and swimmer safety. The model will be used to identify the point of diminishing returns in terms of optimizing any single subsystem relative to the performance of the entire system. There are significant implications of these results in terms of producing regulations, designs, and standard operating procedures that will actually be effective at protecting public health. The findings will emphasize important research needs and guide the aquatics industry toward efficient allocation of resources to prevent future outbreaks and reduce the microbiological risks to swimmers worldwide.

THE EVALUATION OF 24 HOUR RAPID *PSEUDOMONAS AERUGINOSA* ASSAY TECHNIQUES, USING A COMMERCIALLY AVAILABLE TEST KIT (PSEUDALERT)

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Comprehensive validation work undertaken by Latis Scientific have proved that for potable and recreational (Swimming pool/spa/hydrotherapy water) water matrices the Pseudalert method is more reliable than the traditional method filtration method using Pseudomonas CN agar currently quoted in the blue book guide "The Microbiology of Drinking Water (2010) Part 8. The isolation and enumeration of Aeromonas and *Pseudomonas aeruginosa* by membrane filtration". The Idexx Pseudalert test kit method offers laboratories the benefit of detecting the presence of confirmed *Pseudomonas aeruginosa* at 24-28 hours compared to 40-48 hours for a presumptive positive result by the traditional membrane filtration technique using Pseudomonas CN agar followed by an additional 18-24 hour confirmation stage. Pseudalert can be used as a presence/absence test or as a Most Probable Number (MPN) enumeration method. A confirmed positive result is shown by the fluorescence of the well under UV light. Actively growing strains of *Pseudomonas aeruginosa* have an enzyme that cleaves the substrate in the reagent to produce blue fluorescence under 365nm ultra violet light. Trials undertaken in our laboratory have shown that for potable water, both methods had very high confirmation rates (98% for Pseudalert positive wells and 99% for presumptive *Pseudomonas aeruginosa* on CN agar) from a total of 918 samples analysed. For recreational waters Pseudalert maintained a high confirmation rate for positive wells (94%) compared to a much lower rate for presumptive *Pseudomonas aeruginosa* on CN agar (80%) from a total of 116 samples analysed. Both methods had no false positive results (defined as a presumptive postive result in one method which failed to confirm, with the other method showing a negative result) from potable water samples. However on Recreational (Swimming pools/spas) water CN agar had 4.2% false positive rate compared to a 0.9% false positive rate with Pseudalert. The validation work also showed comparability of the results relating to linearity and ensuring the performance relating to 95% confidence intervals is satisfactory too. These results indicate that this method is more robust in the presence of significant numbers of non target organisms which are likely to occur in a recreational water which tests positive for *Pseudomonas aeruginosa*. Pseudalert is easy to use, produces confirmed results within 24 hours and minimizes the risk of false positives from non target organisms. Latis Scientific became the first laboratory in the UK to gain accreditation for the use of Pseudalert in July 2012.This method was used for testing water at the Olympic sites during the games which required a fast response.

PERFORMANCES AND PITFALLS OF FREE-LIVING AMOEBA INFECTIONS DIAGNOSTIC

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Acanthamoeba are microscopic free-living protozoa (single-cell organism) found in water and soil that can cause severe infections of the eye, skin, and central nervous system, etc. They can be spread through contact lens use, cuts or skin wounds or by being inhaled. Infective keratitis is an ocular emergency, which requires prompt and appropriate management to ensure the best visual outcome. The clinical diagnosis of keratitis does not give an unequivocal indication of the causative organisms because a wide range of agents can produce a similar clinical picture, and without adequate treatment the corneal infections may lead to blindness. The common laboratory techniques for detecting and identifying protozoa are based on direct microscopic examination (smears provide information in circa 50%), culture and NAATs (Nucleic Acid Amplification-based Techniques). Direct microscopic detection and identification of agents on fixed specimens using Giemsa and Gram stains, fluorescence, etc. may show *Acanthamoeba* cysts (10-25 µm in diameter) with two walls and pleomorphic trophozoits (15-45 µm). We identified numerous *Acanthamoeba* diagnostic pitfalls directly associated with the quality and topography of sampling: the material for microbiological investigation should be sufficient for smears and/or cultures and/or molecular diagnosis and if necessary to preparation of additional slides. Moreover, the lack of negative predictive value of protozoa detection is associated with A- specimens with reduced amounts of tissue, fluid, etc. obtained from the site were the agent replicates (for keratitis it is recommended a deep scraping in the edge of the lesions and of the infiltrates after assessment of corneal depth by pakimetry); B- insufficient training of technicians and pathologists in charge of smear interpretation (wrong statements while assessing differential images); C- inappropriate elimination of fluorescein or its derivatives (introduction in the sample of fluorophore traces provoke Taq-polymerase inhibition and false negative NAATs results)-; D- topical anesthetics, heparin and its derivatives or antibiotics (aminoglycosides, etc.) (in the samples they reduce NAATs performances); E- biocides, disinfectants or preserved eye-drops from previous treatments (false negative or delayed results, especially culture); F- inappropriate enzymatic or non-enzymatic (NaOH, KOH, etc.) protozoa cyst-lysis that may not allow to release DNA from the complex rigid cyst structures; G- NAATs not detecting all the strains associated with pathology; H- NAATs with mediocre specificity that detect molecular sequences other than those related with searched protozoa; J- molecular probe stability, and K-uncontrolled primer dimerization during the amplification process. Improvement of positive and negative predictive test-rates to minimize these pitfalls were developed and validated with specific targeted procedures.

ADENOVIRUS AS SWIMMING POOL VIROLOGICAL QUALITY INDICATOR

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Several authors reported that half of recreational water-related outbreaks events occurred in swimming pools due by a variety of microorganisms, which may be introduced in a number of ways. In many cases, the risk of infection has been linked to faecal contamination of the water originated by bathers or input water while non-faecal human shedding (*e.g.* from vomit, mucus, saliva or skin) is a potential source of pathogenic organisms. Most of them are enteric viruses such as rotavirus, norovirus, adenovirus, astrovirus, enterovirus and hepatitis A virus. For this aim, a quality index, demonstrating the viral presence and predictive of health effects in swimming pool would be useful. At the moment the suggested recreational water quality standards, are bacterial indicators, such as intestinal enterococci and *Escherichia coli*, related to sewage contamination, and somatic coliphages that are similar to pathogenic enteric viruses concerning environmental attenuation. However it's well known the lack of a consistent correlation between these indicator organisms and viral pathogens. Among waterborne viruses, special attention should be given to Human Adenoviruses (HAdV) because they have a number of features that justify their indication as a virologic marker for the quality of water. HAdV are members of the genus *Mastadenovirus* in the *Adenoviridae* family, which comprises 52 serotypes classified into 7 species (A-G). The wide presence in environmental waters and its resistance to disinfection treatment justified its utilizing as indicator. During several monitoring campaigns of our Laboratory, HAdV were successfully detected after concentration of water samples by ultrafiltration and analysis using biomolecular tests (PCR and quantitative PCR) in seawaters with a mean positive samples of 20%, rivers (80%), sewage systems (100%) and treated waters (40%). The average viral concentration ranged from a maximum of 8.79 Log Genomic Copies/L of sewage samples to 3.67 Log GC/L for seawaters, 3.53 Log GC/L for river waters and 2.3 Log GC/L for treated ones. The same samples were parallel analyzed by ISO methods for suggested quality standard cited above (*E. coli*, intestinal enterococci and somatic coliphages) and quantitative data were often statistical not correlated with HAdV, even in some viral positive seawater and treated waters the values are very low under directive limit. Our data are in compliance with other published studies regarding positive viral samples frequency and quantity, confirming the possible role of HAdV as indicators for water quality. They could be particularly important in swimming pools considering also their resistance to chlorine end their involvements in outbreaks occurring.

IDENTIFICATION AND CHARACTERIZATION OF MICROBIOLOGIC CRITICAL POINTS IN SWIMMING-POOL SURFACES

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Introduction. Environments adjacent to swimming pool tanks can promote microbiological and fungal dissemination to surfaces and to pool water.

Objectives. To ascertain critical points related to contamination in surfaces surrounding swimming pools; to evaluate the efficacy of cleaning/disinfection; to evaluate the relation between contamination in surfaces and in water.

Methods. For a year (September/2011 to September/2012), 151 swabs in surfaces and 26 water samples were collected in a swimming pool and a spa pool from a hotel in Oporto. Sampling locations were defined according to accesses to the premises by professionals and/or pool users, and it included: pool technicians' areas, toilets and showers, contact areas with hands/feet of bathers, passageways, and bathers themselves. It was taken into account: time after cleaning, type of users (hotel guests or not), number of bathers. Samples were collected 3 and 12 h after surfaces cleaning.

Results. No contamination was found on walls, floors or accessories (door handles or lockers) of toilets and showers, nor in empty footbath. A considerable microbiological contamination (coliforms, *E. coli*, *Pseudomonas*, *Staphylococci* and/or fungi) was found in water collections over pavements, in water-filled footbath, on steps/ladders and in Turkish bath equipment. No association was found with number or type of users, but with each bather individual condition. Even after a vigorous shower, 75% of skin swabs from bathers revealed the presence of germs and 37.5% of coliforms. It wasn't found no relation between surfaces contamination and pool water quality. Cleaning and disinfection of surfaces was less effective than expected in contributing to a lesser contamination status.

Discussion and conclusions. Wet bathers seem to have an important role on contamination of surfaces, related with walking barefoot and so contributing to water collection over pavements (being considered the most relevant vehicles in water/surfaces/water contamination). In the absence of other risk control measures, previous passage through water-filled footbath wasn't considered an adequate control measure, neither the shower taken by bathers before using pool tanks. The relative lack of efficacy in cleaning/disinfection could be related with cross-contamination of used cleaning devices or due to light cleaning procedures. On the other hand, a supplementary cleaning/disinfection procedure in the mid-afternoon didn't seem to contribute to a lesser germs growth on surfaces in evening samples.

LEGIONELLA SPP SURVIVAL AFTER DIFFERENT DISINFECTION PROCEDURES: COMPARISON BETWEEN CONVENTIONAL CULTURE AND EMA-QPCR

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Quantitative real-time-PCR (q-PCR) is largely used to evaluate different pathogens in both environmental and clinical samples, including *Legionella* spp Advantages on traditional culture include the high sensitivity, accuracy and rapid evaluation of germ contamination. The main disadvantage is that this method does not distinguish dead/viable cells, a relevant aspect in case of continuous disinfection like in swimming pools. This study presents a new quantitative PCR method using ethidium monoazide (EMA) to detect only viable cells. The comparison with conventional culture can further inform on culturable and VBNC (viable but not culturable) *Legionella* spp. To develop the new test, experiments have been conducted with *L. pneumophila* ATCC 33152. We compared EMA addition at different concentrations on both viable cells during exponential growth period and dead cells. After DNA extraction, q-PCR reaction was made using LightMix kit *Legionella* spp with amplification of the fragment 386 bp of 16S gene. Water samples from swimming pools and hot water distribution systems treated with both chlorine and other disinfection procedures have been collected for analysis by EMA-qPCR. All samples have been also analysed with conventional culture (ISO-11731) to isolate *Legionella* spp. EMA in the range 100-6 µM was able to completely inhibit DNA amplification in samples containing dead legionellae at concentration of $3x10^5$ UFC/L. In contrast, EMA at concentrations of 6 µM did not reduce the q-PCR results on viable *Legionella.* However, higher EMA levels were associated with partial inhibition of DNA amplification on viable cells due to dye toxicity. The analyses on real water samples are still in course. Our results confirm that the Ema-qPCR can represent a new procedure able to distinguish dead and viable legionellae. We underline the need for a balance between EMA toxicity and efficacy, depending on *Legionella* spp concentration. The results of this method on water samples collected from both swimming pools and hot water distribution systems will be useful to compare EMA-qPCR and culture in evaluating differences in dead/viable/culturable germ cells according to various disinfection procedures.

CLEANING DEVICES MAY BE SOURCES FOR *PSEUDOMONAS AERUGINOSA* CONTAMINATIONS IN SWIMMING POOLS

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Although swimming pool water is routinely chlorinated, microbiological contaminations are observed at times in pool water as well as in surrounding “dry” pool areas. In contrast to drinking water, *Pseudomonas aeruginosa* is routinely monitored in swimming pools: samples are usually taken directly out of the basin as well as from the treated water entering the pool. Whilst detection of *E. coli* or coliform bacteria is rare, *Pseudomonas aeruginosa* is the reason for most of the positive microbiological test results. As *P. aeruginosa* is a facultative pathogen, the detection of this microorganism is taken as a serious deficit and measures need to be taken. Usually high chlorine concentrations (up to 20 mg/L) are applied overnight. Here we report about *Pseudomonas aeruginosa* contaminations occurring repeatedly in two swimming pools. DNA sequence analysis suggested that each pool was contaminated by a different strain. Both pools are located in the same city and measures to fight the contamination were of limited benefit. During the detailed examination of all items and sites coming into consideration for the contamination, automatic robot cleaner devices turned out to be sensitive towards contaminations with *P. aeruginosa*. Our results clearly indicate that recontamination with *P. aeruginosa* occurred if the cleaning device was not properly cleaned and dried after use. However, some manufacturers of cleaning robots state that their devices should not fall dry. *Pseudomonas aeruginosa* may easily form biofilms on surfaces, however, there are differences in biofilm formation and growth. Therefore we examined growth of *P. aeruginosa* on different surface samples using a laboratory scale experimental onset. Biofilms were monitored using confocal laser microscopy and staining of living and dead cells. In parallel, chemical examinations of surfaces were performed. Our findings indicate that TOC measurements on surfaces may be an easy indicator for biofilm growth on surfaces, including items like pool cleaning robots.

Session IV

Occupational safety and health promotion

Chairperson

J. Bakker, M. Vitale

HYDROGEN SULFIDE: CHEMICAL AND BIOLOGICAL INTERACTIONS IN SPA WATERS

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Hydrogen Sulfide (H_2S) is a molecule dissolved in many thermal spring waters at variable concentration. The interaction of this molecule with molecules present in an aqueous environment can lead to the generation of organic sulfur compounds. At the same time, biological molecules can be modified (reduced) inducing interesting effects on living beings. Chemical physical and biological issues related to H_2S will be reviewed. A partial list of organic compounds present in recreational waters has been investigated for its reactivity with hydrogen sulfide in different chemical and physical condition, including changing in pH and temperature typical of thermal Spa waters. The list includes aminoacids, lipids, monosaccarides, but also macromolecules like peptidoglycan (murein), keratin, polysaccharides (with different glycosidic bonds), agar (polygalactose sulphate). The whole of the data will allow to define a new frame for the role of Sulfur in recreational waters as well as for its appropriate management.

AQUATIC ENVIRONMENTAL EXPOSURE AND OPERATION QUESTIONNAIRE STANDARDIZATION AND VALIDATION

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Current survey tools for estimating swimmer health lack assessment of exposures related to swimmer behavior and pool operational factors that contribute to injury and illness. No current tool is capable of being issued electronically or is self-administered, and no one tool is used uniformly by outbreak investigators, which may be impeding outbreak-related data collection and analysis. We developed self-administered exposure and operations questionnaires capable of electronic distribution for use by outbreak investigators. Both questionnaires were tested in a swimming pool exposure study that aimed to collect information about swimmer behavior and pool operational risk factors commonly associated with outbreaks, but not well researched. The exposure questionnaire was issued to 126 swimmers in Tucson, Arizona recruited on-site at 2 public pools, and off-site at 2 private pools. The operations questionnaire was issued to the 4 pool sites. Participants completed the questionnaire either on-site using tablets, or through email using a personal computer. Forty two participants submitted a 24 hour urine sample to quantify pool water ingestion. These participants were instructed to swim at least 45 minutes. Swimmers completing the questionnaire only were instructed to swim their "typical" durations. Measured water ingestion volumes quantified through urinalysis were compared to volumes reported on the questionnaire. Data on type of swimming, duration of each type of swimming, swimmer skill level, frequency of deep swimming, notice of a chlorine smell, use of swim aids and diapers, shower use, frequency of pool visits, average visit duration, age of first pool visit, and current respiratory, eye, ear, skin, and gastrointestinal health conditions were collected with the exposure questionnaire. The operations questionnaire inquired about mechanical and structural maintenance, operations, bather loading, and water chemistry conditions. The same exposure questionnaire was issued one week after the observed swim to assess health changes and recall. Water samples were collected during each visit and analyzed on-site for pH, temperature, and free, combined, and total chlorine. Hourly bather numbers from the time the pool opened to the time the last participant exited the water were collected. The average reported frequency of pool visits per year, time spent at the pool facility per visit, and age at first pool exposure were 72 times/year (±66), 1.5 hr (±1.00), and 2.76 years (±2.87), respectively. All participants ingested an average of 13 mL/hr of pool water (±22); 23 mL/hr (±28) if 18 or younger; and 11 mL/hr (±14) if older than 18. There were statistically significant associations at the 95% confidence level between gender and water ingestion (P-value 0.039), age and water ingestion (both measured and reported) (P-values 0.009 and 0.009), diving and measured water ingestion (P-value 0.001), deep water swimming and reported water ingestion (P-value 0.005), length of swim during pool visits and asthma (P-value 0.039), swimming in the past 2 days and using Pepto Bismol in the past 2 weeks (P-values 0.035), and using Pepto Bismol in the past 2 weeks and reporting diarrhea in the past 2 weeks (P-value 0.000). The questionnaires are available online for use by outbreak investigators.

EVALUATION OF HYGIENIC AND SAFETY CONDITIONS IN SWIMMING POOLS: A PROPOSAL FROM THE ITALIAN WORKING GROUP "MOVEMENT SCIENCES FOR HEALTH"

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The Working Group "Movement Sciences for Health" (WGMSH) of the Italian Society of Hygiene, Preventive Medicine and Public Health promotes scientific activities in the field of hygiene, health promotion and education, targeted at enhancing health and physical activities in all age groups. Based on different scientific experiences previously conducted at local level, the WGMSH promoted a national survey aimed to investigate hygienic and safety conditions in swimming pools by using a standardized evaluation check list. The Project has two main objects:

1) evaluating, at national level, both the hygienic and safety conditions in swimming pools and their compliance with national laws and standards;
2) evaluating the standardized check list proposed, in order to be used as tool for official inspections at national level, not only in swimming pools but in other sport facilities too.

A check list, divided into 11 sections reporting items related to the main structural and functional features of the swimming pools facilities, has been developed. In the first part of the check list, general information regarding the facility and the owner are required. Questions regarding measures and plans for risk managements and the number of employees are included too. At the moment, the project is in its first phase: the validation of the check list. As a matter of fact, a pilot study has been carried out in six Italian Cities (Bari, Bologna, Genoa, Naples, Parma, Rome). The questionnaires were fulfilled by Environmental Health Officers, together with specialists in movement sciences and physical activities, during official inspections. Preliminary results underline that attention should be paid in balancing the two aims; in fact, in order to obtain detailed information regarding the hygienic and safety conditions, the use of the check list, as inspection tool, could become difficult. The collaboration among the evolved Universities and Local Health Units, with their specific competences and responsibilities, will help this limitation to be avoid.

REVIEW OF THE LITERATURE ON SWIMMING RELATED EXPOSURES AND ASTHMA IN CHILDREN: IS A META-ANALYSIS POSSIBLE?

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We performed a search in PUBMED on childhood asthma and swimming related irritant exposures. Studies on improvement of asthma in high risk groups as a result of swimming, biomarkers studies focusing on CC16 and SpA and SpB, and studies among adults, were excluded from the study base. The search finally yielded 15 studies. One manuscript involved a letter to the editor and one a paper more similar to an extended abstract. Other hits involved full papers. These were studies published in and since 2003. Studies involved increasing population sizes over the years. The early studies had a few hundred participants, the later studies had several thousand participants. Among the later studies, three were (birth)cohort studies. Most studies were questionnaire based and only few included either lung function or serological information as objective endpoint information. Exposure information was generally also based on questionnaire data involving baby swimming, cumulative pool attendance or other variables reflecting swimming exposure. In only three studies the use of measured trichloramine levels was explicitly mentioned. Because different endpoint variables were studied in the different studies (present asthma or symptoms, ever asthma) as well as different exposure variables, a meta-analysis summarizing the associations in a pooled estimate of association is not possible. A few particular quality issues might have played a role in the early studies related to the so called ecological fallacy. Generally, the more recent and larger cross-sectional as well as cohort studies should be considered as informative but negative studies. Some of the early studies might have generated false positive results either because of their limited size (power) or because of some methodological issues.

ASSESSMENT OF WATER QUALITY OF SOME SWIMMING POOLS IN TIRANE, ALBANIA

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This study was carried out aiming the assessment of water quality of some outdoor pools. This is necessary to protect the health and safety of their users. The study was conducted in six outdoor pools in the city of Tirana, on which there are large number of users belonging to different age groups. These pools have different structural characteristics (surface, volume) and disinfection ways. The study was conducted within a period of three years. Sampling is conducted in various days, on the end-week when their attendance is on maximum and on week days, and on stated daily intervals. The assessment of the quality of these waters was made by monitoring physical and chemical, microbiological and maintenance indicators and by their comparing them with Albanian standards. Physical and chemical indicators were measured two to three times per day connected with management maintenance indicators. Analysis methods are analytical methods in accordance with the Albanian standards ISO, EN Physical and chemical indicators analyzed are: temperature, free chlorine, suspended matter, pH, ammonia, alkalinity, calcium hardness, TDS, etc. Microbiological indicators analyzed are: *total coliform, faecal coliform, faecal, streptococcus*, *pseudomonas aeruginosa*. Maintenance indicators include: the area available per each sunbather, the usage of annexes as public environments, sanitation services, etc. The results of this study showed that some of the indicators are out of the standard rates. Free chlorine in 49.6% of the analyzed samples is out of the standard values. *Total coliform* in 70% of the analyzed samples are out of the standard values. The report of the area per each sunbather in all pools is not managed by their keepers. I can say that in the early hours of the day physical and chemical indicators are generally within standard values, but with the increase of the number of bathers their chemical balance changes, so introduced above values are out of the standard. This happens because these pools have manual disinfection system.

Conclusion**.** Safety in swimming pools requires water quality and maintenance management in accordance with bathing load.

SWIMMING POOLS AND SPAS: ONE-EYE IN THE LAND OF THE BLIND

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Presented are three cases of health problems for visitors and bath attendants in Dutch chlorinated swimming pools, forcing two to close temporally. We outlined how work-related health problems of bath attendents and visitors were examined (and solved) by the Netherlands Center of Occupational Diseases, together with the Expertise Center of Occupational Dermatology. Further we demonstrate the success of a project-based approach with multidisciplinary crisis teams in cases of forced closure of pools and the necessity of aftercare.

Session V

Monitoring, surveillance and prevention

Chairperson
K. Pond, S. Caroli

EVALUATION OF ATMOSPHERIC CHLORAMINES IN UK POOLS

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A total of 11 establishments in the UK have been considered as part of this study. These establishments included both public and school pools that were treated by a variety of disinfection processes. The objective was to evaluate the air quality obtained with water quality conditions and ventilation practices. Air quality measurements were made to establish the concentration of free chlorine, monochloramine, dichloramine and nitrogen trichloride using a combination of DPD measurements and ion chromatography. The results obtained were related to numbers of bathers using the pool, the relative humidity, installed air conditioning system, and water quality test results undertaken at the time of air sampling for temperature, free chlorine, monochloramine, dichloramine and nitrogen trichloride. The study confirmed that the lower the chloramine content of the water the lower the chloramine concentration was in the air. Subjective assessment of the atmosphere provided a good correlation with analytical results and that irritant effects of nitrogen trichloride were detectable subjectively below 0.5 mg/m^3, raising the question as to whether or not this limit is low enough. Whilst nitrogen trichloride was found in the atmosphere it was not detected in any of the pool waters examined. Results suggest that a better air quality may be achieved using a two part disinfection process of sodium hypochlorite and sodium bromide for disinfection. Controlling environmental conditions by maintain air temperature at no more than 1°C above water temperature and relative humidity between 60-70% and avoiding recirculation of air and dehumidification assisted to provide the best air quality results.

QUANTIFICATION OF CONTINUAL ANTHROPOGENIC POLLUTANT RELEASE IN SWIMMING POOLS

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The amount of pollutants brought into the swimming pool water by swimmers is called anthropogenic pollutant release. The continual pollutant release is the amount of pollutants which is released during the submerged swimming period. The actual level of the continual pollutant release has not been studied individually up till now. The objective of this study was to define and quantify the individual continual pollutant release both chemically and microbiologically at different swimming pool conditions and different levels of exercise.
The continual release was studied with a standardized exercise during time-series lab experiments. During these experiments, participants entered a preconditioned pool tank after having a pre-swim shower to remove the initial pollutant release. To prevent dilution of the continual release, participants were wearing a waterproof suit, filled with 50 L non chlorinated tap water. The participants each had a 10 minute rest period subsequently followed by a 30 minute exercise on aqua-nordic-walker to simulate a swimming exercise, both submerged in the waterproof suite. During the experiment, the tap water inside the waterproof suite was circulated for good mixing and conditioning. Periodically samples were taken and analyzed for Total Organic Carbon (TOC) as well as Total Nitrogen (TN). Other parameters like urea, ammonium, nitrate, turbidity, UV254, particle count, total cell count and ATP concentration were also analyzed. Sweat production was calculated by balancing the participant's weight before and after each experiment. Assuming that the water temperature and the level of exercise are the most important factors influencing the continual release, the experiments were performed at different temperatures (25, 30 and 35°C) for each participant. First results show a low calculated sweat production by balancing of 70-100 g per participant in 30 minutes, while the chemical results show an even lower sweat rate of 10-15 g per participant in 30 minutes. Both results are lower than the up till now expected sweat release of 200-1,000 g/h. Possibly there is also some sweating from the unsubmerged skin, being the shoulders and the head. Also some weight loss can be explained by moist in the exhaled air. To confirm these new assumptions, more experiments will be done in October 2012.

FRACTIONATION OF SWIMMING POOL WATER: THM AND NCl_3 FORMATION KINETICS

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Even though, chlorine has been shown to be an effective disinfectant in Swimming Pool Water (SPW), it is known to react with aqueous Natural Organic Material (NOM) under formation of a variety of Disinfection By-Products (DBP). The most important and recently discussed examples of volatile DBPs found in SPW, which have been associated with adverse health effects, are Trichloramine (NCl_3) and Trihalomethanes (THM). Previous studies have shown that beside the concentration, the chemical structure of NOM is the most decisive factor for the formation of these DBPs. In order to understand and predict DBP formation in SPW, chlorination experiments were performed using single substances or mixtures of single substances, so called Body Fluid Analogues (BFA). However, the BFA mixtures represent just small selection of all substances and substance classes which are introduced in the pool system by bathers or by filling water. One meaningful way to access the diversity of the entire NOM present in SPW for DBP formation experiments is to divide it into NOM fractions. In this context the primary objectives of this study were: 1) to evaluate and understand the formation kinetics of NCl_3 and THMs by chlorination of different NOM fractions found in SPW and 2) to corroborate or deny the fact if other nitrogen compounds than urea found in SPW are relevant NCl_3-precursors. Since SPW had already exhaustive reaction time with free chlorine, also the non-chlorinated NOM sources found in swimming pool facilities, namely filling water and bather load samples, were examined. As already developed in past studies, a High Performance Size Exclusion Chromatography (HPSEC) technique was used to physically separate the water samples gaining the following NOM fractionations: 1) biopolymers, 2) humic acids, 3) building blocks, 4) low molecular weight acids and 5) low molecular weight neutrals. Before and after HPSEC separation the NOM fractions were characterized according to their carbon, UV and nitrogen content using the LC-OCD method. Subsequently, the separated NOM fractions were normalised to an equal concentration of Dissolved Organic Carbon (DOC) and then chlorinated. First analysis of non-separated SPW and filling water samples using the LC-OCD method showed that the NOM composition of the SPW samples correlated to the NOM composition of the filling water. It was found that a significant amount of nitrogen was bound in the high molecular weight fractions. This nitrogen may play a significant role for NCl_3 formation. The amount of nitrogen incorporated in urea relative to the total amount of nitrogen varied in a range of 40-80%. After pre-concentration, the water samples could successfully be separated into the five NOM fractions using the preparative HPSEC technique. After fractionation ~95% of the dissolved carbon content of the unfractionated samples could be recovered in the fractions. Recently, the separated NOM fractions are used to perform chlorination experiments.

CHLORATE AND BROMATE IN SWISS SWIMMING POOLS

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The properties of disinfecting agents influence directly the concentration of certain Disinfection By-Products (DBPs). This is the case for chlorate and bromate. These DBPs accumulate in pool water because no filter retain them. During eight years, 553 samples from 42 public pools have been analyzed. These pools are proceeded according to the Swiss norm SIA 385/9 which defines a reference value for chlorate (<4 mg/L) and tolerance values for chlorate (10 mg ClO_3^-/L) and bromate (0.2 mg BrO_3^-/L). 16 pools used Bulk NaClO, 15 $Ca(ClO)_2$, 8 electrolyse of NaCl producing NaClO, 4 electrolyse of HCl producing HClO; 1 gaseous chlorine, 3 the procedure NaBr-ozone, and 2 ozone only. During the study, seven pools changed the type of treatment, what allowed us to make interesting comparisons.

Bromate. Only two disinfectant types resulted in measurable bromate concentrations: NaBr-ozone results in a median of 0.99 mg BrO_3^-/L, and a maximum at 2.0 mg BrO_3^-/L (n=19); and bulk hypochlorite with a median at 0.04 mg BrO_3^-/L and a maximum at 1.4 mg BrO_3^-/L. (n=105). These concentrations are statistically different.

Chlorate. The type of disinfectant greatly influences the chlorate content ($p<0.001$, Likelihood ratio test), and has more impact than additional treatments such as UV or ozone. The highest contents were found in water treated with bulk NaClO (median=8.1 mg ClO_3^-/L, n=179, max. 109.4 mg ClO_3^-/L) and with electrolysis producing NaClO (median=5.2 mg ClO_3^-/L, max. 26.9 mg ClO_3^-/L, n=106). The 10 mg ClO_3^-/L SIA tolerance value was not respected in respectively 42.5% and 21.7% of analyses. These high variations could be issued from inappropriate storage or *in situ* production of disinfectants at too high temperature. The median content of chlorate with other disinfectants were clearly lower than those with both NaClO treatments and the variations were smaller. With $Ca(ClO)_2$ the median was 2.26 mg ClO_3^-/L and only 3/156 analyses were above the tolerance value. With electrolysis producing HClO, the median was 0.27 mg ClO_3^-/L (n=36). These results suggest that these treatments are less affected by maintenance or employees manipulations. Statistical analysis indicates that the factors *ozone*, *UV*, *indoor vs outdoor pool*, *pool type* as well as the *substance used to regulate pH* influence significantly the chlorate concentration. However, these statistical differences are not always consistent throughout disinfectant types. Pool history shows that chlorate and bromate accumulate until water is fully exchanged and can reach concentrations of concern such as 100 mg ClO_3^-/L. This is also true with an input of 30 Liters of fresh water per bather as required by SIA Norm. This observation has important implications for authorities since any control performed the weeks after a total water exchange would not provide useful information on DBPs status. we formulate recommendations to avoid that swimming water becomes too much contaminated with bromate and chlorate.

HAZARDS CAUSED BY SUCTION INTAKES IN SWIMMING POOLS

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In many swimming pools water is removed from the tank by means of suction pipes in order to feed it to the treatment plant, to several water-fun attractions or to the measuring systems. It has been known for a long time already that these intake systems may cause an increased hazard potential for bathers. During the last few years, Europe has seen severe accidents again and again caused by suction intakes - in some cases having caused the death of the bather. The European standardisation bodies and national rule providers have submitted standards which shall rule out accident hazards at suction intakes in swimming pools. However, the requirements of these guideline rules are in opposition to each other in parts. In addition, the existence and the significance of the guideline rules to prevent accidents with suction intakes are not known to ally operators of swimming pools. In this respect, intensive information of the swimming pool operators is still required. In many cases the bathers also contribute to an increase in the hazard potential at the suction intakes. By wearing hair open, having jewellery and piercings whilst swimming in the pool and using swimming wear with a large surface of material (such as Bermuda trunks), the accident hazard may increase significantly at suction intakes. In some cases, it could be established that bathers intentionally behave manipulative and covered the suction intakes with their body. A high number of swimming pools are not aware of this new type of behaviour and “fashion fads” of the bathers. Frequently the suction intakes, pumps and pipe systems have been placed according to mere functional aspects. Frequently safety equipment is absent to prevent or minimise the risk of accidents. The hazard potential can be reduced considerably in existing plants as well by retrofitting safety equipment, such as by replacing unsafe covering grids of the suction intake by safe ones. Equipment for force ventilation of suction pipe can be added and safety switches can be used to shut down pump when critical low pressure is dropped short. The lecture provides an overview of the various hazards at suction systems in swimming pools and report about real accidents. In addition, the requirements of the guideline rules are explained, and possibilities for increasing the safety standard on suction systems are demonstrated. In this respect the special demands for reconstruction of existing plants are taken into consideration. In case of expert planning and execution and in case of expert operation, accidents at suction plants should be avoidable in future.

Session VI

Water treatment and pool management

Chairperson

W. Uhl, G. Fantuzzi

TECHNICAL REQUIREMENTS TESTING AND CERTIFICATION OF AC, UV, AND WQTD SYSTEMS FOR RECREATIONAL WATER USE IN NORTH AMERICA

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Introduction. NSF International (NSF) has several standards and programs involving the testing and certification of performance and health effects of water treatment and distribution products for many end uses such as residential drinking water treatment, industrial and waste water treatment, public or municipal drinking water treatment as well as the recreational water treatment. NSF/ANSI Standard 50: Equipment for Pool, Spa, Hot Tub and Other Recreational Water Facilities (Ann Arbor, MI, USA: NSF International; 2012) is the all encompassing product and system evaluation criteria for evaluation of products and materials used at recreational water facilities. This presentation will discuss new developments and criteria that have been developed for the Recreational Water and Aquatics Markets, specifically evaluation, testing and certification of ultraviolet (UV) light systems, automated chemical system controllers (AC), and Water Quality Test Devices (WQTD).

Discussion. Together UV water treatment, Automatic Controllers, and Water Quality Test Devices help to assure excellent water quality for swimmers. This presentation will teach attendees how each of these products function, and how they are tested and certified and how use of certified products increases facility safety. After many water park cryptosporidiosis outbreaks in the US, new and more robust regulations were drafted and promulgated by many states (NY, FL, CA, TX, UT). The regulations addressed Auto Controllers, Flow Meters, UV, etc. NSF issued final harmonized specific testing methods and evaluation criteria for third party testing and certification of UV systems. The NSF Standard 50-2010 incorporated new requirements that include a more specific and repeatable derivative of the Long Term 2 Enhanced Surface Water Treatment Rules (LT2ESWTR) and United States Environmental Protection Agency Ultra Violet Disinfection Guidance Manual (USEPAUVDGM) (Cincinnati, OH, USA: USEPA Environmental Monitoring and Support Laboratory; November 2006), as well as requirements from DVGW W-294 and ONORM 5873 for UV drinking water UV system evaluation criteria via MS2 phage. NSF/ANSI Standard 50 also includes important and challenging criteria for the technical evaluation and performance testing of automated chemical control systems (AC). The evaluation criteria for automated chemical control systems include both short and long term tests, chemical resistance and life tests. This presentation will explain the technical evaluation requirements and testing as well as the benefits in use of certified systems. NSF/ANSI Standard 50 also includes new and challenging evaluation and testing criteria for the Water Quality Testing Devices (WQTD) such as photometric, liquid reagent, solid test strip technologies for use in water chemistry analysis. The requirements address rapid detection and feedback test kits which can be used to perform different water chemistry analyses including, flow measurement, pH, chlorine, bromine, total alkalinity, calcium hardness, cyanuric acid, temperature, salt, copper, silver, iron, TDS, etc. The evaluation and testing program includes requirements for different levels of accuracy and repeatability from production lot and within a production lot. NSF has therefore developed a certification program to test the performance and verify manufacturing production controls for recreational water products. NSF Standard 50 has been updated with important harmonized criteria for UV system testing (aka validation), and certification of automatic controllers UV systems, and water testing devices to ensure water safety.

CFD STUDY OF FLOW FIELD IN DIFFERENT PUBLIC SWIMMING POOLS

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Bacterial and chemical water quality in swimming pools is regulated by precise and stringent guidelines set out by the World Health Organization and most national authorities. Health authorities in many countries are very concerned about identifying and quantifying chlorination by-products. In the relevant literature, most reports describe monitoring results of different chemical species in pools over time; kinetics of by-products formation, on-site studies, are not available. However, a couple of laboratory-based kinetic studies of chloramines formation have been proposed. The highly complex chemistry of chloramines formation is an obstacle to deeper knowledge in this field, especially for the development of predictive kinetic models applicable in real situations. Another problem is widespread lack of understanding of hydraulic behavior in pools, which has been treated by very few studies. A public swimming pool can be considered as a chemical reactor with specific hydraulic and macro-mixing characteristics. The nature of flow into the pool depends on various characteristics, such as water inlets and outlets (number and position), pool geometry, and flow rate. This study investigates how swimming pool design affects hydraulic behaviour based on experimental and Computational Fluid Dynamics studies (CFD). This paper does not describe the hydraulic behavior of all existing public swimming pools, however the cases studied here are representative of pool designs widely used in Europe and the United States. Experimental and simulation results allowed the development of simple hydraulic model. It is based on the principle of a stirred reactor and could be used as a first approach in describing the hydraulic behavior of regular pools. This model is suitable for the study of physical and chemical phenomena with long characteristic times *e.g.* urea chlorination. Other, more advanced models will be better for the study of fast processes such as reaction scheme for chlorination of ammoniacal water. The stirred reactor model can be extrapolated to pools with similar geometric configurations and operating modes to the pools studied, without requiring a CFD approach. This would be particularly convenient for kinetic applications, including prediction of chemical species concentrations in the pool, or to optimize chlorination and daily water renewal. Beside it is important to remember that this study has been performed in the absence of swimmers. Pool attendance should increase water mixing, accentuating resemblance to a stirred tank reactor.

HOW DOES SWIMMING POOL WATER TREATMENT AFFECT FORMATION AND REMOVAL OF DISINFECTION BY-PRODUCTS: FIRST EXPERIENCE USING A PILOT SCALE SWIMMING POOL MODEL

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By their nature, people bathing in a pool dispose considerable amounts of organic constituents into the pool water. However, resulting from reaction of the organic substances with free chlorine added as disinfectant, significant concentrations of Disinfection By-Products (DBPs) are formed. A wide range of DBPs found in swimming pool water are known from the literature and most of these halogenated reaction products (amongst others trihalomethanes: THMs and trichloramine) are characterized as eye and skin irritating, carcinogenic or as triggers of respiratory problems and should be removed as far as possible from swimming pool water. Besides often used conventional treatment methods novel treatment steps, namely UV-treatment, also seem to achieve high removal rates for DBPs. However, the intense UV-irradiation of swimming pool water shows disadvantages as structural alternation of organic substances may cause high DBP formation potentials. Many studies found in literature deal with single pool water treatment steps. In contrast the aim of our study is to optimize pool water treatment regarding the total system indoor swimming pool including basin, air in the hall and water treatment. For this purpose a pilot scale model was designed following German standards which allows good comparability to real indoor swimming pools by considering a high number of important system parameters and their interactions. Main part of the pilot scale model is a covered pool of 2.7 m^3. The input of organic matter by the bather was simulated by adding "body fluid analogue" (BFA), which is comprised by typical constituents of human sweat and urine. Pool water was treated continuously in the water treatment cycle (568 L/h) composed by the splash water tank, flocculation with aluminum followed by ultrafiltration (MWCO: 100 kDa), UV-radiation, chlorine-dosing and pH-adjustment. In our studies two experiments were carried out so far. In experiment one a UV-low pressure lamp (340 W/m^2) was used. Experiment two was operated under application of a UV-medium pressure radiation (4200 W/m^2). Samples were taken and analyzed fully automated from the pool and after the particular treatment steps. Amongst others the on-line monitoring included concentrations of free and total chlorine and TOC. Volatile DBPs were measured by on-line membrane introduction mass spectrometry (MIMS). Results of experiment one showed a decrease in free chlorine concentrations by UV-low pressure radiation due to photolytic decomposition. Attributable to the non-stop dosing of organic matter TOC and total THM (TTHM), concentrations in pool water were high (5.9 mg TOC/L and 29.7 µg $CHCl_3$/L respectively) compared to real indoor-pool conditions. Trichloramine concentrations were measured to 94 µg/L. TTHM and combined chlorine levels seemed to be affected only by air stripping effects by entering the splash water tank whereas concentrations of trichloramine decreased by 60% along the

water treatment line by air stripping and photolytic decomposition. In experiment two TTHM concentrations decreased by 13% due to air stripping and by further 22% in the UV-medium pressure radiation step. Furthermore, nearly complete depletion of free and combined chlorine, including trichloramine, was observed at the UV reactor outflow. However, THM and trichloramine levels in pool water (53.1 µg $CHCl_3$/L and 251 µg/L respectively) were significantly higher than the ones observed in experiment one. This can most probably be attributed to structural alternation of organic substances by UV medium pressure radiation resulting in increased DBP formation potential. In summary it can be concluded that, although trichloramine can be removed widely by UV medium pressure radiation, application of this technique should be applied only after efficient reduction of DBP precursor concentrations as it causes significant increase of DBP formation potential.

MINIMUM CHLORINE CONCENTRATION IN SWIMMING POOLS TO ENSURE DISINFECTION

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Chlorine is present in most swimming pools as residual disinfectant. In the Netherlands, the chlorine concentration in swimming pools has to be between 0.5-1.5 mg/L free available chlorine, which is based on a 4-log removal of *Pseudomonas aeruginosa* within 30 seconds. The disinfection of chlorine is based on the penetration of the negatively charged chlorine-products through the negatively charged cell wall of microorganisms. Inside the cell, the chlorine interacts with enzymes leading to inactivation or cell death. Besides this positive reaction of chlorine, side reactions occur. Disinfection By-Products (DBPs) are formed, which are irritating and can be harmful to swimmers health. One way to lower the formation of DBPs is by lowering the chlorine concentration to a minimum level, where disinfection is still sufficient. In this study the objective was to determine this minimum allowed chlorine concentration in swimming pools, based on a mixed microbial population present in swimming pools and compare this to the needed chlorine concentration based on an indicator microorganism. The minimum free available chlorine concentration was studied during lab experiments in which the chlorine concentration was a changed. Samples were taken in time and analyzed with different methods like total cell count (live/dead staining), plate count, DNA concentration measurement (with Nanodrop) as well as qPCR, to compare the outcome of the experiments. Of the indicator microorganisms for swimming pools (such as *Pseudomonas aeruginosa*, *Staphylococcus aureus*, streptococci and *E. coli*) *E. coli* was added to non-chlorinated and chlorinated water. Next, to determine the minimum chlorine concentration in a swimming pool a more realistic mixed microbial population was used. The mixed microbial population was obtained from non-chlorinated bathing water assuming that the microorganisms present in swimming pools are released by bathers which should be released also during bathing in a bath tub. First results show a 4-log removal of the *E. coli* bacteria within 30 seconds at a free chlorine concentration of 0.59 mg/L. The mixed microbial population is showing a higher chlorine tolerance. About 50% of the microorganisms were inactivated within 10 seconds at a free chlorine concentration of 0.51 mg/L. In time an increase of cell elimination was observed as well.

EVALUATION OF SWIMMING POOL WATER QUALITY USING SUM PARAMETERS FOR ORGANIC CARBON

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Quality of swimming pool water is difficult to define. Whilst absence of pathogenic microorganisms is clearly imperative, chemical parameters serving as indicators for good swimming pool water quality are much harder to define. DIN 19643 lists threshold limit parameters for a variety of chemical parameters that may be employed. However, whilst the limitation of free chlorine, THM and chlorate is understandable from a toxicological point of view, other parameters are not self-explaining. Whilst drinking water is regularly examined for the sum of organic compounds using Total Organic Carbon (TOC), in swimming pool water examination of oxidizability using $KMnO_4$ as an oxidizing agent prevails. In comparison, TOC indicates organic compounds completely, whilst oxidizability only indicates a certain group of compounds defined by their ability to unspecific oxidation. For this study, we collected data for TOC and oxidizability over a period of 4 years. Whilst both parameters show plausible results comparing basin- and treated water, results for TOC and oxidizability are not directly comparable and the data sets show different distribution functions. Problems regarding high chloride and/or sulfate concentrations were not observable. An objective interpretation of both kinds of data is not feasible, therefore interpretation of data relies on experience. However, from a scientific point of view the metrological background of TOC is better defined and reproducible. All data examined so far clearly indicate that TOC should be taken as a quality parameter describing organic contaminations rather than oxidizability.

OPTIMIZATION OF HS-SPME ANALYTICAL CONDITIONS USING FACTORIAL DESIGN FOR THMS DETERMINATION IN SWIMMING POOL WATER SAMPLES

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Trihalomethanes (THMs) are a group of volatile organic compounds that may result from the reaction between chlorine or bromine and organic precursors present in swimming pool water. Thus they are also classified as Disinfection By-Products (DBPs). The THMs most commonly detected are Chloroform (TCM), Bromodichloromethane (BDCM), Chlorodibromomethane (CDBM), and Bromoform (TBM). The formation of these compounds has drawn public attention because of their possible link to health effects in users and staff of such installations. Several studies regarding the determination of THMs in swimming pool water and air have been published. This paper reviews the most recent work in this field, with a special focus on water and air sampling, sample preparation and analytical determination methods. The techniques covered for swimming pool water samples preparation are Direct Aqueous Injection (DAI), Liquid-Liquid Extraction (LLE), Purge and Trap (P&T), Solid Phase Extraction (SPE), and Headspace Solid-Phase Microextraction (HS-SPME). Regarding air samples, techniques such as Direct Injection (DI), P&T, SPME, and solid sorbent have been reviewed. In both cases compounds are normally separated by capillary Gas Chromatography (GC) and quantified using an Electron Capture Detector (ECD) or a Mass Spectrometry detector (MS). An experimental study has been developed in order to optimize the HS-SPME extraction conditions of TCM, BDCM, CDBM and TBM from water samples using a 23 factorial design. The best conditions obtained were an extraction temperature of 45°C, an extraction time of 25 min and a desorption time of 5 min. Analysis was performed by GC-ECD. The method was successfully applied to a set of 27 swimming pool water samples. TCM was the only THM detected with levels between 4.5 and 406.5 μg/L. Four of the samples exceeded the parametric value for total THMs in drinking water (100 μg/L) established by the European Directive 98/83/CE.

Session VII

Poster

POSTER - SESSION II

1-II EMISSIONS OF CHLORINATION BY-PRODUCTS IN THE ATMOSPHERE OF INDOOR SWIMMING POOLS - DEVELOPMENT OF A METHOD FOR THE MEASUREMENT AND ANALYSIS OF THE INFLUENCE OF OPERATING PARAMETERS ON A REFERENCE SWIMMING POOL

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Epidemiological studies have shown adverse effects on health associated with exposure to chlorine in swimming pools, such as increased permeability of the lung epithelium, respiratory problems and asthma. Thus, the measured values show that concentrations of Trichloramine (NCl_3) into the air above 0.5 mg/m^3 can produce effects on the health of workers or categories of swimmers (as children or swimmers practicing regularly). These NCl_3 concentrations in the air depend on the air exchange and the emission potential of NCl_3 by the water of the swimming pool (concentration in water of chlorine and precursors of NCl_3 formation, dissolved NCl_3, agitation by swimmers and water games...). Therefore, to limit the presence of precursors in water, it can be proposed more important makeup water or to implement, on the recirculation of water in the pool, a process to reduce the concentration of volatile compounds based on water desorption (stripping in the buffer tank or stripping tower), or by UV irradiation (UV dechloramination). However, some problems persist despite the implementation of these recommendations and of these materials. The objective of this presentation is to describe the approach and means used to establish a relationship between the occurrence of precursors (urea, chlorine, organic carbon), the reaction conditions and the exposure to trichloramine in air and in recreational waters in confined spaces. The methodology is based on two complementary approaches. The first relates to the development of a suitable measurement protocol to quantify the various chlorinated species in air and in water. Particular attention is paid to the sampling method of gas (flow chamber) and the methods for the determination of NCl_3 and its precursors in liquid and gas phases (ion chromatography, MIMS...). The second line of research focuses on the coupling between the hydrodynamics of the pool environment and chlorine chemistry (reactions and transfer liquid/gas) from measurements in a pool dedicated to experimentation. For this, chemical engineering methods with experimental approach (Residence Time Distributions) are used. This approach allows the characterization of the pool reference through its hydrodynamic behaviour to understand the reaction medium in which the study of transfer is conducted, and secondly to extrapolate the results obtained on this particular case pool reference to any studied system. The innovative character of the study is to develop a predictive approach to NCl_3 and chlorination by-products emissions in the atmosphere of indoor swimming pools, from full-scale experiments taking into account all the influential parameters. Then it will be proposed a protocol which allows the optimization of operating parameters in indoor swimming pools due to the extrapolation potential of the presented approach through an actual site.

2-II COMPARISON OF ANALYTICAL OPTIONS FOR UREA IN POOL WATER

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Urea is detected in swimming pool water due to that it is the main form of reduced nitrogen excreted from bathers. A maximally allowed limit for the concentration of urea in pool water has been used in some countries as a parameter to control that sufficient filling water is used relative to the bather load. In the last decade the importance of urea as the main precursor for trichloramine has been realized and this has increased the interest in monitoring the urea concentrations in pool waters. Urea reacts slowly with chlorine to form chloroureas which reacts further with chlorine to form trichloramine without any inorganic chloramines as intermediate products. At pH 7.2 more than half the nitrogen in urea will end as trichloramine. Trichloramine falls under suspicion of being the main initiator of the observed increasing prevalence of asthma in competitive swimmers. It has been reported in literature that besides the chemical reactions with chlorine the factors that determines the urea concentration in pool water are the load as determined by the number of bathers who use the pool and the pre-swim hygiene (showering with use of soap) and removal reactions like water dilution and the use of specific treatment technologies such as ozonation, medium pressure UV and activated carbon. To investigate the effect of all these factors it is necessary to measure urea directly in pool water. In recent literature 3 analytical methods have been used to quantify urea in pool water. An indirect method of analysis relies on the enzymatic hydrolysis of urea by the enzyme urease to ammonium which is then quantified colorimetrically. Two direct colorimetric methods are based on the reaction of urea with diacetylmonoxime in acidic conditions. In the first method in the presence of antipyrine a strong yellow color develops which is quantified by measuring the samples absorbance at 466 nm. In the second method thiosemicarbazide, phosphate and iron(III) causes development of a red color which is quantified by measuring the samples absorbance at 520 nm. We applied all 3 methods to samples taken from local public swimming pools with different use patterns and with very different water treatment technologies applied. The analytical methods have initially given inconsistent results with real samples while control samples of urea spiked into filling water gave acceptable results. We discuss the nature of this apparent matrix problem and some possible fixes.

3-II INFLUENCE OF UV-A LIGHT ON GASEOUS NITROGEN TRICHLORIDE IN AIR - AN EXPERIMENTAL STUDY

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Volatile disinfection by-products, such as Nitrogen Trichloride (NCl_3), produced in water by the reaction of chlorine with nitrogen compounds, induce eye and respiratory irritations in swimming pool for workers. The aim of this study is the assessment of the impact of natural/artificial light radiations on NCl_3 contained in swimming pool. The physical properties of NCl_3 mean that it should be possible to destruct this molecule by UV photolysis. Some studies showed that nitrogen trichloride could be broken down using short-wave UV light irradiation. Experiments were performed in laboratory under conditions of UV-A light flux, temperature and relative humidity close to those usually measured in the hall of swimming pools. However, for of analytical sensitivity aspects, NCl_3 concentration was chosen intentionally higher than value observed on site. The results of the study demonstrate the photo-bleaching of NCl_3 by the absorption of UV - A radiation. The radical mechanism of photolysis of NCl_3 induces the formation of Cl_2, which itself absorbs UV light irradiation to varying extents between 250 and 350 nm, leading to the formation of $Cl^{\bullet}$ free atoms. These species also can enhance NCl_3 decomposition and lead to an apparent quantum yield of NCl_3 degradation greater than unity. The photon can thus be absorbed by one NCl_3 molecule leading to degradation of six NCl_3 molecules. It is, however, possible to suggest branching chain decomposition mechanism. Additional studies will be necessary to determine the precise nature of the observed reactional mechanism. From this work, it is possible to assess the conversion rate of gaseous nitrogen trichloride in oxidizing chlorine into indoor air of swimming pool. The first conclusion of the study is that the decomposition of gaseous NCl_3 by solar irradiation in indoor swimming is very low and should contribute to weak production of oxidizing chlorine in air.

4-II KINETICS OF CHLOROFORM FORMATION DURING CHLORINATION OF SWIMMING POOL WATER

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Chlorination of swimming pool water is an essential part of the water preparation process. However, chlorine is a strong oxidant as well as a chlorinating agent and will form Disinfection by Products (DBPs) with organic and inorganic compounds in the water. Chloroform is one of the DBPs formed in relevant amounts. Other Trihalomethanes (THM) may be formed if halogenides other than chloride are present in the water. However, most waters in central Germany are low in bromide and therefore brominated THMs are only formed in neglectable amounts. From a worldwide point of view, water disinfection using bromine or bromide salts in combination with chlorine is a common practice. If bromide containing salts are added, the mechanism of THM formation will change rapidly, and only bromoform will be formed instead of chloroform. Thus, this reaction may be employed to examine and to compare chloroform and bromoform formation rates on site. To this end, lab studies were performed using standard compounds present in body fluids to analyze kinetics of chloroform and bromoform formation. Finally, this approach was repeated on a large scale basis in a pool without swimmers. Results indicated that bromoform formation instantaneously starts after the addition of bromide salts to the water. From this moment, no more chloroform is produced but only bromoform. However, GC/MS analyses show the presence of several other DBPs. Finally, bromide was added in small amounts to the water of a swimming pool during normal operation. Results indicate here as well, that chloroform formation stops immediately and formation of bromoform may be observed. Results indicate, that bromoform concentrations in the water rises to higher concentrations than chloroform, and that chloroform disappears from the water within hours. This approach may be used to calculate equilibrium concentrations of chloroform formation and chloroform outtake.

5-II THE GERMAN SWIMMING POOL COMMITTEE - A GLIMPSE INTO OUR WORK

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The German Swimming Pool Committee is a national expert commission of the Federal Ministry of Health (BMG) - located at the Federal Environment Agency (UBA). She advises both public authorities in matters of swimming pool water hygiene. The BMG appoints jointly with the Federal Ministry for Environment, Nature Conservation and Nuclear Safety and the highest competent state authorities, members of the Committee for a session of three years. Membership in the Committee is honorary. The Committee members are from academic institutions, state agencies and public health departments. In addition to the appointed members and permanent guests, including representatives from Austria and Switzerland, the meetings are also attended by the representatives of the Ministry of Health, the Ministry of Defense and the UBA. If necessary, the Commission invites additional experts to support the work. The possibility that the UBA may be assisted by a special committee is set out in the Federal Protection Against Infection Act and clearly shows the importance this topic is assigned by the legislature. The Committee discusses current issues and problems of swimming pool water hygiene and makes recommendations, especially to protect the health of bathers. These recommendations are published and serve the public health authorities and pool managers as a basis for action. The significance of the Committee's work is enhanced by the fact that apart from the Federal Protection Against Infection Act there exists no legal regulation concerning the quality of pool water or the protection of bathers. Important issues that have been discussed during the last years have been the prevention of childhood asthma due to disinfection by-products, the role of chlorate and bromate in swimming pools, how to manage high legionella contaminations, hygiene requirements of swimming pools, management by pool owners and monitoring by public health authorities. The German technical rule for swimming pools has been revised during the last years substantially. Members of the Committee are also members of the technical committee at the German Institute for Standardization and provide their specialized knowledge. Currently the recommendations for pool owners and public health authorities are revised in order to reflect the new technical regulations and amendments thereof. Following this, a check list for the survey by a public health department is being developed.

6-II CHEMICAL CHARACTERISTICS AND PROPERTIES OF THE GELLÉRT SPA WATERS, BUDAPEST

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The bath establishment was built between 1912 and 1918 in the Art Nouveau (or Secession) style. References to healing waters in this location date back to the early 13th century. A hospital was located on this spot during the Middle Ages. During the rule of the Ottoman Empire, thermal baths were also built on this particular site. The "magical healing springs" were used by the Turks during the 16th and 17th centuries. At that time the bath was called Sárosfürdő, *i.e.*, muddy bath because of the mineral mud which settled at the bottom of pools. Medical uses of this water include the treatment of degenerative joint illnesses, spine pathology, chronic and sub-acute joint inflammation, vertebral disk problems, neuralgia, vasoconstriction, circulatory disturbances, asthma and chronic bronchitis. The chemical composition of thermal waters at the Gellért bath was found to be (in mg/L): Br^-, 0.43; Ca^{2+}, 180; Cl^-, 142; F^-, 2.31; I^-, 0.03; K^+, 17.4; Mg^{2+}, 54.4; Na^+, 122; HCO_3^-, 555; NO_3^-, 0.4; S^{2-}, 0.72; and SO_4^{2-}, 359. Furthermore, Ra^{226} and Rn^{222} concentrations were measured as 467 mBq/L and 326 Bq/L, respectively. From a balneological viewpoint, Ca and Mg bicarbonates play a key role because of their anti-inflammatory and skin regeneration effects and of the diffusion of Ca into the bones. A number of other anions show similar effects. In its turn, Rn^{222} is a well known vasodilator, capable of fighting arteriosclerosis as well as of reducing blood pressure. Measurements were performed by VITUKI (the Hungarian Research Institute for Environment and Water Management) by means of Inductively-Coupled Plasma Atomic Emission Spectrometry (ICP-AES), Flame Atomic Absorption Spectrometry (FAAS), IC (Ion Chromatography) and α-Spectrometry (αS). Further determinations by Inductively-Coupled Plasma Mass Spectrometry (ICP-MS) are in progress as regards selected trace elements, *e.g.*, As, B, Co, Cr, Li, P, S, Se, Ti, V and Zn, useful to reconstruct the process of formation of caves within the Gellért mountain.

7-II PREVALENCE OF SELF-REPORTED CUTANEOUS SYMPTOMS IN SUBJECTS WORKING AT INDOOR SWIMMING POOLS

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As a part of an Italian study on health effects of swimming pools employees, the aim of this study was to investigate the prevalence of self-reported cutaneous symptoms in subjects working at indoor swimming pools, as some epidemiological studies suggested high prevalence rates of eczema in subjects working inside the pool water as trainers, pool attendants and hydro therapists. Information about the health status of 133 employees was collected by a structured questionnaire. The questionnaire recorded demographic characteristics, lifestyle, working related activities (kind of job, number of working hours by day and week, previous or parallel jobs) and symptoms related to cutaneous apparatus (verruca, mycosis, eczema and rash). Most of the swimming pool workers were females (52.6%), with a mean age of 33 ys, non-smokers (48.9%), working in swimming pools for an average of 8 years: no statistical differences were observed. The employees had a mean work engagement of 25.2±14.1 hour/week corresponding to 4.7±2.4 hour/day. According to the questionnaire data, 50% of the subjects had attended indoor swimming pools for more than 20 years, mainly as swimmers. The prevalence of cutaneous diseases in all the investigated subjects was: rash (20.3%), verruca (16.5%), mycosis (15.8%) and eczema (9.0%). However, subjects who declared to spend some hours inside the pool water during their working activities experienced generally more verruca (20.8% *vs* 3.1%), mycosis (17.8% *vs* 9.4%) and eczema (9.9% *vs* 6.2%) than other employees without any activities in the pool water. Rash frequency was very similar (20.3% and 21.9%) in both the categories of workers. This study confirms that lifeguards and trainers are more at risk for cutaneous diseases than subjects with other occupations at swimming pool facilities. However, even though our study does not specifically include hydro-therapists, we did not find more eczema or rash in trainers who entered the pool water during their teaching activities when compared with other investigated employees.

8-II RESPIRATORY AND OCULAR SYMPTOMS IN SWIMMING POOLS WORKERS AND AIRBORNE TRICHLORAMINE (NCl_3) EXPOSURE

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The aim of this cross-sectional study was to investigate the association between airborne NCl_3 exposure in indoor swimming pools and the prevalence of self-reported respiratory and ocular symptoms in occupationally exposed subjects. Twenty indoor swimming pools in the Emilia Romagna region of Italy were included in the study. Information about the health status of 128 employees was collected using a structured questionnaire. Exposure to airborne NCl_3 was evaluated in indoor swimming pools by a modified DPD/KI method. The airborne NCl_3 levels showed a mean value of 0.65 ± 0.20 mg/m^3 ranging from 0.2 to 1.02 mg/m^3 with. More than 50% the swimming pools showed airborne NCl_3 levels higher than 0.5 mg/m^3 (recommend WHO guidelines). Both ocular and upper respiratory symptoms were very frequent in the investigated employees: red eyes, runny nose, voice loss and cold symptoms were declared more frequently by pool attendants (lifeguards and trainers) when compared with employees working in other areas of the facility (office, cafe, *etc.*). Pool attendants exposed to airborne NCl_3 levels higher than 0.5 mg/m^3 experienced higher risks for runny nose (OR: 2.9; 95% CI: 1.22-6.94) red eyes (OR: 3.2; 95% CI: 1.5-6.8), voice loss (OR: 3.6; 95% CI: 1.6-8.0), itchy eyes (OR: 2.2; 95% CI: 1.0-4.8) than other employees. When very high levels of airborne NCl_3 were taken into account (airborne NCl_3 levels ≥0.80 mg/m^3 *vs* <0.80 mg/m^3) ocular and respiratory symptoms became much more evident, with higher risks (as ORs) in exposed subjects (lifeguards and trainers) compared with other employees. This study confirms that lifeguards and trainers are at risk for respiratory and ocular irritative symptoms more than other employees in indoor swimming pools, in particular in presence of high airborne NCl_3 levels.

9-II BROMATE, CHLORITE, CHLORATE, HALOACETIC ACIDS (HAAS), AND TRIHALOMETHANES (THMS) DETERMINATION IN INDOOR SWIMMING POOLS

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People attending indoor swimming pools are exposed to Disinfection By-Products (DBPs) by ingestion and also by dermal contact and/or inhalation, as a consequence of water disinfection treatments with chlorine and related compounds. The occurrence of Trihalomethanes (THMs) in pool waters has been well documented while information about the presence of other DBPs (bromate, chlorite, chlorate, haloacetic acids) in indoor swimming pools is very limited and needed to be further investigated as some of these substances are potentially dangerous for human health. The aim of this study was to investigate the presence of bromate, chlorite, chlorate, halogenated acetic acids and THMs in some Italian indoor swimming pools in order to evaluate the potential exposure in competitive swimmers and pool attendants. In this study, starting from February 2005 in the Emilia Romagna Region, in the North of Italy, 24 indoor swimming pools were investigated. THMs were evaluated with a standardized method involving the head-space gas chromatographic technique while HAAs, bromate, chlorite, chlorate were detected by ion chromatography with mass spectrophotometry. THMs, bromates, chlorates and chlorites and HAAs were investigated not only in pool waters but also in water feed. THMs were present in all the pool water samples (41.4±30.0 µg/L), while they were present above the detection limit in only 50% of the water supply: in the latter, the average concentrations of THMs were generally low (4.8±1.5 µg/L), a consequence of the treatments for drinking water disinfection with chlorine dioxide, widespread in Italy. Bromate has never been detected in water supply samples, while it was observed only in 3 samples of pool water (range: 10-48 µg/L). Chlorite were present in 15 samples of water supply and only in one sample of pool water. Chlorates have been detected in high concentrations in pool waters, with a mean value of 4717±5758 µg/L. Regarding to haloacetic acids, the levels ranged from 11 to 403 µg/L, with a mean value of 170±122 µg/L. In people attending swimming pools, the health risks from exposures to THMs, bromate, chlorite and haloacetic acids can be considered to be small. However, the high levels of chlorates sometimes observed should be further evaluated for their potential effects even if, at the moment, there is no epidemiological evidences and/or associations between environmental exposure to these compounds and human health.

10-II CHLORITE AND CHLORATE - A NEW REGULATED SUM PARAMETER FOR SWIMMING POOL WATER QUALITY IN GERMANY

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Chlorate and Chloride are inorganic disinfection by products, which emerge in pool water directly by decomposition of the disinfectant (hypochlorite). This process is accelerated by warm temperatures and sunlight (UV radiation). Chlorite is unstable in the pool water and decays quickly to Chlorate. Because Chlorate cannot be removed by water treatment, it accumulates over months in the pool water. Especially when sodium hypochlorite is used to unhealthy levels in the bath water may occur (up to 100 mg/L and more) that possibly can cause mucosal irritation and nausea. This is because sodium hypochlorite already decays to chlorate under adverse storage conditions. In the newly revised German regulations (DIN 19643 - November 2012) the chlorate problem was first considered. Because of the toxicological mechanism for chlorite and chlorate is identical (methemoglobin formation, decreased transport of oxygen in the blood) it was introduced a sum parameter. The new German guidance value of 30 mg/L for the sum of chlorite and chlorate in the bathing water is based on a toxicological evaluation, based on the Tolerable Daily Intake (TDI) and considering the special conditions in Germany. In principle, Chlorate can enter the body through the ingestion of chlorinated drinking water and chlorinated pool water. Because the German drinking water is chlorinated rarely (and then only in low concentration), more Chlorate can be ingested through bathing water, than in many other countries where drinking water chlorination is stronger. Pool operators now face the challenge to create technical conditions that ensure compliance with the new guidance value during a transitional period of 5 years. Our studies show that Chlorate is formed only in very low concentration in the pool water when chlorine gas is used as a disinfectant. It can be problematic, however, when sodium hypochlorite is used, even if it is generated onsite via membrane cell electrolysis. This is due to the storage conditions, but also on economic measures to reduce fresh water consumption. Minimization strategies will be discussed from the perspective of the operator.

11-II OXYBENZONE UV FILTER DEGRADATION BY CHLORINE IN SEAWATER SWIMMING POOLS AND EVIDENCE OF BROMOFORM FORMATION

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Ultraviolet (UV) filtering compounds are being added to Personal Care Products (PCPs) like cosmetics and sunscreens in order to protect individuals from the harmful effects of UV radiations. Various organic UV filtering compounds are found in many PCPs and can constitute up to 10% of the product's mass. These compounds are derivatives of aminobenzoic acids, cinnamates, salycylates, benzophenones. These compounds, such as other body fluid compounds brought by bathers (urine, sweat, hair, skin), may react with continuous inputs of high chlorine doses in swimming pools. To date, there have been few investigations regarding the reaction of UV filters in chlorinated waters. Recently, experiments carried out -under laboratory controlled chlorination conditions- with Octyl-Dimethyl-Paminobenzoic Acid (ODPABA) and oxybenzone have shown that these UV filters readily reacted with available chlorine through two proposed degradation pathways. The proposed degradation pathway for ODPABA consists of electrophilic substitution of chlorine on the ortho- carbons to the amino moiety, resulting in monohalogenated products. For oxybenzone, the phenol moiety was ortho/para directing, resulting in mono- and dihalogenated substitution by-products prior to ring cleavage and formation of halogenated forms of 3-methoxyphenol. In French thalassotherapy centres, seawater is disinfected following the same legislation as drinking water feeding the swimming pools, that is to say with a value of residual of free chlorine ranging from 0.4 to 1.4 mg/L Cl_2 in the case of basins disinfected by bleach or chlorine gas, or an amount of at least 2 mg/L Cl_2 when stabilized with isocyanuric acid. However, the addition of chlorine into bromide-rich water conducts to the formation of Hypobromous acid (HOBr), which is more reactive with organic matter than Hypochlorous acid (HOCl). Moreover, has been observed during previous studies, during summer periods, thalassotherapy user behaviour pattern, alternatively consists in self-tanning outside the pools and in cooling himself down inside the pools, bringing thus in the pools a cocktail of organic compounds ready to react with HOBr. Very little is known about the kinetic rate of benzophenone UV filter degradation and the formation of stable transformation products in the presence of aqueous chlorine in seawater. Therefore, the transformation of a commonly used UV filter, Oxybenzone (OXY) was investigated in the presence of various aqueous chlorine levels. UV filter chlorination experiments were conducted under pseudo-first-order conditions with total chlorine to UV filter molar ratios of 1:1, 10:1 and 25:1 and at 25°C, 30°C and 35°C (UV filter concentration fixed to 0.1 mg/L). Trihalomethane (THM) formation kinetics has been followed during 1-hour experiment, by spiking sample every 10 minutes and by GC/ECD analysis. Bromoform ($CHBr_3$) was the most abundant THM found (500 µg/L with the 10:1 ratio experiment), followed by Dibromochloromethane ($CHClBr_2$).

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POSTER - SESSION III

1-III ASSESSMENT OF A CAMPAIGN TO PROMOTE HEALTHY SWIMMING BEHAVIORS AFTER A STATEWIDE OUTBREAK OF CRYPTOSPORIDIOSIS ASSOCIATED WITH RECREATIONAL WATER VENUES - UTAH, 2008-2009

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Introduction. Cryptosporidium, a parasite that is transmitted via the fecal-oral route, has driven the significant ($p<0.001$, negative binomial regression) increase in the incidence of recreational water-associated outbreaks in the United States. In 2007, Cryptosporidium caused a statewide outbreak of gastrointestinal illness in Utah. Approximately 5,700 outbreak-related cases were identified across the state. Of 1,506 interviewed patients with laboratory-confirmed cryptosporidiosis, 80% (1,209) reported swimming in at least one of approximately 450 recreational water venues during their potential 14-day incubation period. Swimmers are the primary source of Cryptosporidium contamination of treated recreational water venues (*e.g.* pools), and the parasite is extremely tolerant to chlorine, the primary barrier to pathogen transmission in these venues. Healthy swimming promotion campaigns could increase awareness and practice of healthy swimming behaviors, particularly not swimming while ill with diarrhea (i.e., a behavior that can lead to contamination of recreational water). Before the 2008 summer swimming season, Utah public health agencies launched a multimedia healthy swimming promotion campaign. Subsequently, we collaborated to assess the public's knowledge of healthy swimming and the effectiveness of the campaign.

Methods. In July-September 2008, the Utah Department of Health surveyed 499 adults about their awareness of the outbreak, campaign, and healthy swimming behaviors. During August-September 2009, 4,556 (65%) of a nationally representative sample of 7,004 households in the continental United States completed and returned postal surveys. Statistical significance ($p<0.05$) was determined using Rao-Scott adjusted chi-squares.

Results. The results of the Utah survey found that 96.1% of respondents correctly indicated that "it is not OK to swim if you have diarrhea." In the national survey, 100% of Utah residents but only 78.4% of residents of other states (p-value not calculable) correctly identified "not swimming when you have diarrhea" as a healthy swimming behavior. Additionally, 96.4% of Utah residents compared with 85.7% of residents of other states correctly identified "not swallowing water you swim in" as a healthy swimming behavior ($p=0.046$). No recreational water-associated outbreaks were detected in Utah during 2008-2011.

Conclusions. Utah's healthy swimming promotion campaign might have helped prevent recreational water-associated outbreaks caused by Cryptosporidium and other pathogens. Over 20% of the U.S. public does not know that swimming while ill with diarrhea is unhealthy; effective healthy swimming promotions must successfully reach this group.

2-III *PSEUDOMONAS AERUGINOSA* ON INFLATABLES AND FOAM TEACHING AIDS IN SWIMMING POOLS

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Pseudomonas aeruginosa is an opportunistic human pathogen which is intrinsically resistant to a broad range of antibiotics. It is a common inhabitant of soil and water environments, and thrives in the warm and humid swimming pool environment, where it may accumulate in biofilms. Swimming pool related *P. aeruginosa* infections result in otitis externa and folliculitis. Public swimming pools in the Utrecht region in The Netherlands were invited to participate in a study that determined the presence of *P. aeruginosa* on pool inflatables and foam teaching aids. Fourteen swimming pools were enrolled, and visited during September-December 2011. Sampling of the selected equipment was done by swabbing a 10 cm^2 surface with EnviroSwabs: one sample per specimen from foam teaching aids (2-4 specimens per pool), and 3-5 samples per specimen from inflatables and other large objects. *P. aeruginosa* was enumerated by using the Pseudalert Quantitray, and membrane filtration on CN-agar and mPA-B-agar. A total of 87 objects were tested, of which 134 samples were taken. *P. aeruginosa* was found on objects in 10 of 14 (71%) swimming pools; 39 of the 134 (29%) samples were positive with at least one of the methods used. Fewer foam teaching aids (15%) than inflatables and other vinyl canvas objects (51%) were contaminated with *P. aeruginosa*. Large inflatables, like obstacle courses, were far more often colonized than other vinyl canvas objects, with the presence of biofilms clearly noticeable. Wet objects (44%) were more often contaminated than dry objects (15%). The observed *P. aeruginosa* concentrations were variable, method dependent and on average higher on inflatables than on foam objects. All confirmed *P. aeruginosa* isolates (n=177) were tested for their resistance to 12 clinically relevant antibiotics. Seventeen percent of the isolates were (intermediate) resistant to one or more of the tested antibiotics, the majority of these being resistant to monobactams and carbapenems. In most swimming pools, the tested objects were not cleaned and dried after use, or before storage. All swimming pool managers were seldomly notified of skin conditions by visitors that used inflatables or foam teaching aids, but they all mentioned anecdotal cases of skin rash when children used inflatable slides or obstacle courses. In conclusion, wet storage of inflatables and foam teaching aids enhances growth of *P. aeruginosa*; vinyl canvas seems to provide better opportunities for biofilm formation than foam. The presence of carbapenem resistant *P. aeruginosa* warrants attention of pool managers and responsible authorities since treatment of resulting infections may be hampered. Further study into the effect of cleaning, drying or disinfection on (re-)growth or removal of *P. aeruginosa* on swimming pool equipment is needed.

3-III WATER QUALITY IN DR. FISH (*GARRA RUFA*) SPAS

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Dr. Fish or Garra rufa treatments are increasingly popular. These treatments include immersing feet or hands in a tank of water containing Garra rufa fish. Occasionally, facilities offer Garra rufa pools for whole body submersion. The small carps nibble off dead and thickened skin, thus offering a cosmetic treatment for people with a healthy skin. Medical use of Garra rufa fish concerns treatment of people with eczema or psoriasis. Due to the presence of live animals, conventional water treatment and disinfection of the water in Garra rufa pools are not possible, for these would kill the fish. Subsequent clients use the same batch of fish and the water is not replaced after each use. Moreover, the water in fish pools is kept at a temperature of 25-30°C, which will encourage bacterial growth. These practices may result in poor water quality and may enhance transmission of pathogens from fish to man, from water to man and/or from man to man causing a potential public health risk. The presence of known zoonotic pathogens in Garra rufa fish has been demonstrated, but water quality data from Garra rufa pools are scarce. In The Netherlands, these pools are usually outside the scope of current swimming pool legislation because of their size, and therefore routine monitoring of water quality and regular reporting of results is not mandatory. We listed the Garra rufa facilities in The Netherlands through an internet search and contacted a selection of 25 of these facilities. During October-November 2012, at different facilities, water samples will be taken from Garra rufa pools in use, whereas swab samples will be taken from pool surfaces. All samples will be analysed for the presence of *Escherichia coli*, intestinal enterococci, *Aeromonas* spp., *Pseudomonas aeruginosa*, *Vibrio* spp. and non-tuberculous *Mycobacterium* spp.

4-III THE IMPACT OF THE FILTER MAINTENANCE IN *PSEUDOMONAS AERUGINOSA* COUNTS IN POOL WATERS

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Filtration is very important procedure in ensuring the safety of swimmers and the preservation of good water quality. Proper filtration enhances visibility and minimizes injuries. Filtration is critical for the removal of *Cryptosporidium* oocysts and *Giardia* cysts. This study tries to assess the impact of poor filter's maintenance in the microbiological quality of pool water, with emphasis in the *Pseudomonas aeruginosa* survival and growth. In the Greek Sanitary Decree on pool management, the use of medium rate sand filters in recommended. Alternatives should be diatomaceous earth filters. The size of sand grains should be 50μm. They should contain multi-grade beds containing a number of layers of coarse media under a sand bed of 90 cm. A velocity adaptor and a viewing window should be installed on the filters for good performance and maintenance. As for the assessment of the pool microbiological quality, total coliforms <15/100mL, the absence of *E. coli*/100mL and aerobic colony counts <200cfus/mL provide the basis. *P. aeruginosa* and *St aureus* counts are indicated as suitable additional parameters. Free chlorine concentration is indicated as 0.4-0.7 ppm and pH 7.2-8.2. For this study a review of the records of routine sanitary inspection in public pools was carried out. The review revealed 10 pools with *P. aeruginosa* counts of 50-1,000 cfus/100mL. 2/10 cases presented additionally bacterial indicator counts. Free residual chlorine in these pools was 1.65-3 ppm and pH values 7-7.6. According to the Greek legislation and the WHO Guidelines these pools were hyper-chlorinated. In all cases sanitary inspection revealed poor filter maintenance (sand beds were thin, only refilled rather than replaced, presenting cracks and coagulated sand).In another 20 cases *P. aeruginosa* counts were >50cfus/100mL and bacterial indicators of faecal pollution were detected in 5/20 pools. During the sanitary survey it was not possible to control the state of the filters, as a viewing window was not installed. Nevertheless and according to the pool's manager statements, no proper maintenance was carried out in the filters.

Conclusions. These results highlight the importance of good filtration and give an indication that disinfection only does not provide enough protection against the presence of *P. aeruginosa* and other bacteria in the water.

5-III A CASE STUDY OF CUTANEOUS MYCOBACTERIOSIS IN CHILDREN ATTENDING A SCHOOL-ANNEXED SWIMMING POOL

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After the occurrence of 18 cases of cutaneous mycobacteriosis among children attending a school with a swimming pool in Rome, an environmental microbial investigation was carried out for identifying the exposure scenario, detecting the sources of infection and applying environmental hygienic corrective measures. Only two cases were then confirmed by positive culture test and M. abscessus was identified as the etiological agent of the cutaneous lesions. Non-Tubercolous Mycobacteria (NTM) are microorganisms ubiquitous in environment, commonly found in water sources and soil. Some species are important environmental opportunistic pathogens causing a range of infections in humans and animals by ingestion, inhalation, and contact from environmental sources. For NTM cutaneous infections the contact with water and contaminated surfaces represents the most plausible route of infection. Different species are frequently associated with cutaneous diseases acquired in swimming pool. All the infected children attended the swimming pool of the school, thus environmental samples were collected from both the structures. Water samples were collected from the swimming pool, at the water meter which supplies the whole school complex and from taps of nursery and elementary school toilets. By surface swabbing procedures, biofilm samples were taken from the swimming pool edges, the bathroom fittings of the two school toilets and from showers of the toilet annexed to the swimming pool. Microbial analyses required molecular methodologies as PCR, RFLP (restriction fragment length polymorphism) and DNA sequencing. Results highlighted the occurrence of NTM in all water samples with concentrations variable from 29 to 930 cfu/L in water collected from the swimming pool and ranging from 160 to 600 cfu/L in water collected at the water meter and from the two rest rooms. NTM were always found in surface swabs from the showers of swimming pool toilets whilst were not detected on swimming pool edges. The NTM species identified in swimming pool water were M. mucogenicum and M. phocaicum, while the most frequently mycobacteria found in the other water samples were *M. chelonae, M. mucogenicum, M. fredericksbergense* and *M. ilatzerense. M. fortuitum* was isolated from biofilm in the showers, whilst *M. abscessus* was never detected in any environmental sample. Data emphasize no correlation between the exposure at environmental sources and the infection. A delay between the onset of symptoms and the environmental investigation, the lack of rapid and easy analytical methods for NTM research and the incompleteness of diagnosis information could have been responsible of this difficulty.

6-III OUTBREAKS OF CUTANEOUS NONTUBERCULOUS MYCOBACTERIA IN A PRIMARY SCHOOL IN ITALY: RESULTS OF ENVIRONMENTAL INVESTIGATION

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After two outbreak of 25 cases of cutaneous infection caused by *Mycobacterium abscessus* [Nontuberculous mycobacteria mycobacteriosis (NTM)] linked to a swimming pool, which occurred among children of a primary school in Rome during the school year 2009-2010 and 2010-2011, an epidemiological survey focused on the environmental were conducted for detecting principal sources of the contamination and evaluating the efficacy of hygienic procedures. Environmental samples were obtained from February-April 2010 and march 2011 from school water system (tap water) and swimming pool (water, tap water, pool edge, shower tray and shower mat). All samples were collected according to ISO methods. For microbiologic investigations, all samples were analyzed, after appropriate digestion and decontamination, onto culture media (Lowenstein-Jensen medium, BD Biosciences Division, Sparks, Maryland, USA). Media were incubated at 37°C. Colonies were stained with Ziehl Nelsen stain for acid-fast bacteria and processed for strain typing by the reverse hybridization method (Inno-Lipa Mycobacteria v2 Innogenetics, Belgium) and kit GenoType CM (Arnika, Hain Lifescience GmbH, Nehren). Envinromental risk assessment and Good Hygienic Practice (GHP) of the swimming pool were acquired and cheked. Qualitative analysis of the environmental samples revealed the presence of *M. mucogenicum*, *M. phocaicum*, *M. fortuitum*, *M. ilatzerense*, *M. chelonae*, *M. fredericksbergense* and *Gordonia terra after the first cluster, while in the second cluster,* we are *revealed only M. fortuitum in* shower tray. Nevertheless environmental survey did not confirmed the presence of *M. abscessus* in the swimming pool water, the large presence of other NTMs support the role of swimming pool as risk factor. Epidemiological investigation results showed an epidemiological link with the swimming pool and no other possible sources were identified. Mycobacteria hazard is not included in water-quality criteria in Italy, although it is known that standard chlorination of drinking water are non effective to inactivate. The scientific evidence will be support the legal microbiological criteria revision to prevent NTM infection.

7-III DATA OF MICROBIOLOGICAL QUALITY OF SWIMMING POOLS IN TIRANA DISTRICT, ALBANIA

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Microbiological quality is the most important parameter for the safety of swimming pool water. In this paper we present results of microbiological analysis of pool water in Tirana district, Albania during 2011-2012. In total, 84 microbiological pool analyses from 22 indoor and outdoor swimming pools have been performed within a two-year period. All samples were collected into sterile glass with capacities 500 mL and a depth of 30 cm, at a point about 40 cm away from the pool edge and they were transferred to the laboratory at 4°C within 1-2 h from collection, using appropriate insulated coolers and they were processed immediately after arrival at the laboratory. Bacteriological samples were analyzed by the membrane filter technique, using 0.47 mm diameter, 0.45 μm pore size filters as specified in Standard Methods ISO to determine the following parameters: Total Coliforms (TC) per 100 ml at 37°C, Faecal Coliforms (FC) per 100 mL at 44°C, Faecal Streptococci (FS) per 100 mL at 37°C, *Staphylococcus aureus* (SA) per 100 mL at 37°C, *Pseudomonas aeruginosa* (PS) per 100 mL at 37°C. Out of 84 water samples examined, 36 (43%) conformed to the microbiological standards and 57% exceeded at least one of the indicated limits. Total Coliforms (TC) exceeded 0 cfu/100 mL in 36 (43%) samples collected. Faecal Coliforms (FC) exceeded 0 cfu/100 mL in 31 (37%) samples collected. Faecal Streptococci (FS) exceeded 0 cfu/100 mL in 8 (10%) samples collected. *Staphylococcus* Aureus (SA) exceeded 0 cfu/100 mL in 6 (7%) samples collected. *Pseudomonas aeruginosa* (PS) exceeded 0 cfu/100 mL in 8 (10%) samples collected. Results obtained within this data clearly indicate that 43% of all samples did not fulfill the required limits. Swimming pools have been increasingly popular in Albania and poor Microbiological quality might cause public health problems. In our data more than half of investigated pools were contaminated with at least one microbial indicator so they are unacceptable according to the WHO standards. We recommended continuous quality monitoring according to our Directive Nr 835, date 30.11.2011.

8-III FREE-LIVING AMOEBAE AND ENTERIC PROTOZOA ISOLATED IN SWIMMING POOL

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The risk of illness or infection associated with swimming pools has generally been linked to faecal contamination of water. Viruses and bacteria have been often indicated as responsible of many reported swimming pool-related outbreaks. However, in recent years, even protozoa have been reported as a cause of infection. Despite some difficulty in their recovery in water, these organisms have the advantage to survive longer than bacteria and viruses at higher disinfectant concentrations. In this context, a protozoological survey was carried out and free-living amoebae and enteric protozoa (*Giardia intestinalis* e *Cryptosporidium* spp.) were investigated. Water samples were collected at a swimming pool: water in the pool and backwash water of filters were examined. A qualitative analysis was performed for free-living amoebae, isolated by two different cultural methods (Non- nutrient agar and PAS) and microscopic examination. *Giardia intestinalis* and *Cryptosporidium parvum* were detected according to the ISO/CD15553. Free-living amoebae were undetected in the pool water. Conversely, in the backwash water samples, on Non-nutrient agar, 75% of the samples were positive at 30°C and 8% positive at 37°C; in PAS, 92% were positive at 30°C and 33% at 37°C. The analysis performed on the enteric protozoa, also in this case, confirmed the absence of the organisms in the pool water but gave different results in the backwash water: although at low concentration, 30% of the samples were positive for *Giardia intestinalis* while *Cryptosporidium* spp. was always absent. Results highlight the constant occurrence of amoebae recovered both at 30°C and 37°C in the backwash water samples. The absence of these organisms in the pool could be due to low initial concentrations that filters are able to entrapped. Different findings were obtained for the enteric protozoa. In other Italian studies performed by the authors *Giardia* cysts not only were more frequently recovered respect to *Cryptosporidium* oocysts, but also in higher concentrations. Nevertheless, the absence of *Cryptosporidium* does not necessarily mean that it is not present; it could be possible that it is below the limit of detection. Efforts to minimize exposure to specific risks form the foundation of all the prevention activities. Facility administrators and operators should be aware of the requirements to ensure safe and enjoyable use of swimming pool and should be responsible for the good operation and management of the entire system. Thus an adequate management of the water treatment systems before its entrance in the pool must be followed by fully hygienic operations and maintenance.

9-III CRYPTOSPORIDIUM - "THE PARASITE WE ALL WANT TO AVOID"

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Over the past decade the most common setting for waterborne infections in England and Wales has been swimming pools, with cryptosporidium being the leading cause. There are two cryptosporidium species that account for more than 96% of cases within the UK, Cryptosporidium parvum which can be acquired from animals or humans and Cryptosporidium hominis which is accountable to humans. Hominis is more common in the swimming pool setting although both have been found in swimming pools. A parasite that causes acute gastroenteritis cryptosporidium is by far becoming the biggest risk to safe bathing within the UK. Cryptosporidium is regarded as a large threat to Pools and Spas due to numerous reasons; firstly it is highly resistant to the levels of free chlorine that we operate in the majority of swimming pools and spas. This is because the occysts are encased in an impervious shell and the oocyst only hatches once it enters the stomach of the host. Furthermore its size is relatively small, around 5µm in diameter, therefore can potentially pass through the commonly used medium rate sand filter. The result of this is that ingestion by our bathers of fewer than ten oocysts will be sufficient to cause infection and disease. If cryptosporidium is immune to the levels of chlorine that we operate at we must ensure that it is removed during filtration to prevent further spread of infection. Flocculation would be essential to assist in the removal of cryptosporidium or the use of de filter media. Non-residual disinfectant such as UV and Ozone can also assist as they effectively break down and oxidise cryptosporidium. Therefore the use of one or both of these methods, increasing filtration efficiency or a non-residual disinfectant, is essential to the removal of cryptosporidium. However, these methods will only be effective if recommended procedures are followed that includes the closing of pools on the indication of faecal release to ensure sufficient removal of bacteria via a minimum of six turn over cycles followed by a backwash of the filter. If these procedures and guidelines are adhered to, organisations are heading in the right direction to limit the damages of a cryptosporidium outbreak within a pool or spa.

10-III BACTERIA DETECTION IN RECREATIONAL WATER: THE MOLECULAR ENRICHMENT APPROACH

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In the last decades a strong increase in water sports, has been reported enhancing specific epidemiological issues but also new opportunities to enhance safety and hygiene in swimming pool. The identification of rapid methods for the surveillance of recreational waters and aquatic environments is necessary to provide adequate levels of health safety and quality standards. Molecular techniques have been proposed in recent years as a valuable alternative to traditional microbiological culture methods, having numerous advantages (speed, specificity and sensibility). Recently, we described a method for detection of *Staphylococcus aureus* in recreational waters by a molecular enrichment approach. Briefly, the method is based on the specific optimisation of a nested amplification of prokaryotic genomic DNA by the use of universal primers for 23S rDNA; subsequently, a second amplification step is performed with specific real-time PCR primers and probe. The approach has been now expanded to other microbiological indicators, with special focus on *Escherichia coli*. Preliminary tests, however, revealed a background probably due to traces of DNA of *E. coli* in the commercially available reagents. To minimize this problem we tested two different Taq polymerases with minimum contaminating *E. coli* DNA (like Taq-native, non-recombinant *E. coli*). Results showed the absence of the background, opening to promising perspectives. New protocol modifications have been introduced in order maintain suitable sensitivity levels also with these reagents. The increase of the panel of bacteria that can be identified through the molecular enrichment method allows to hope for a future extension of the application to other fields, as occupational safety, food hygiene and public health.

11-III VIABLE, VIABLE BUT NONCULTURABLE AND DEAD BACTERIA: NATS AND PUBLIC HEALTH NEEDS IN RECREATIONAL WATER ENVIRONMENTS

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Microbiological risk is a relevant Public Health topic in swimming pool and similar environments. Historically, microbiological quality of recreational waters has been assessed using culture-based techniques. This approach is particular robust and straightforward for well characterized bacterial strains, but also time consuming. In addition, in some specific conditions, culture-based techniques can underestimate the microbial load due to a variable percentage of nonculturable bacterial cells. Nucleic Acid Techniques (NATs) overcome this problem, being able to identify all genomes present in the environmental sample. Discrimination between viable and dead cells and extracellular DNA has been hypothesized as a limit for NATs applications in the analysis of several matrices. In order to verify this limit in water analysis, several protocols have been tested on samples with viable and dead cells. Preliminary results show the absence of interference by dead cells and extracellular DNA in water samples processed with protocols that do not have filtration steps.

12-III HETEROTROPHIC PLATE COUNT: ROLE AND SIGNIFICANCE IN SWIMMING POOL

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Vigilance of hygienic characteristics of swimming pools in Italy has a long tradition; chemical and microbiological water parameters were already fixed in an Italian ordinance of the Ministry of Health in 1971. The current Italian guidance on "Hygienic aspects for the construction, maintaining and control of swimming pools" entered by then into force ten years ago. It concerns the quality of public freshwater swimming pools and includes all the hygienic aspects related to the swimming pool construction, operation and maintenance, management and vigilance. Pool water must comply with the parametric values established for a set of physical-chemical and microbiological parameters. The assessing of the microbiological water quality include the control of the bacterial indicators of faecal contamination, *Pseudomonas aeruginosa*, *Staphylococcus aureus* and the Plate Count at 22°C and 36°C. For this latter parameter, the Italian guidance provides a value of ≤200 cfu/100 ml and ≤100 cfu/100 ml, at 22°C and 36°C, respectively. Our study directed the attention to this parameter known also as Heterotrophic Plate Count (HPC). It does not differentiate between the types of bacteria present nor does it indicate the total number of bacteria present in the water - only those capable of forming visible colonies under specified conditions on non-selective microbiological media. Microorganisms recovered through HPC tests generally include those that are part of the natural (typically non-hazardous) microbiota of water; in some instances they may also include both organisms derived from diverse pollutant sources and potential pathogens. WHO Guidelines for safe recreational water environments points out the importance of the sudden increase of this parameter that should show low counts in absence of coliforms. It is recommended that HPC be measured regularly in disinfected pools. HPC does not necessarily indicate microbiological safety as the bacteria isolated may not have been faecally-derived but it does give a measure of the overall general quality of the pool water, and whether the filtration and disinfection systems are operating satisfactorily. According to the scientific literature HPC measurements are used to indicate the effectiveness of water treatment processes, thus as an indirect indication of pathogen removal and as a measure of numbers of regrowth organisms that may or may not have sanitary significance. Different evaluations on the investigated parameter derive from the comparison and interpretation of data obtained a the two temperature, during *more than 10 years' experience* in the monitoring of swimming pools.

POSTER - SESSION IV

1-IV GUIDE TO A RISK ORIENTED AUTHORIZATION AND SURVEILLANCE SCHEME FOR PUBLIC POOL AND SPA INSTALLATIONS

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Bathing in waters exposed to direct or indirect microbiological contamination from bathers and other sources is an unavoidable source of hazards and so are the side effects caused by the protective measures against it. Risks should be considered in the context of the bather/service-provider/regulator-supervisor triad not only to avoid the health risks but also other nuisances as far as possible. Our aim is not to assess quantitatively the microbial and other health risks that the bathers may be exposed to, but to reveal the interrelation of the passive occurrences, failures and activities in a pool and spa establishment and to try and find a common *modus vivendi* for the most possible benefits to all participants at the lowest possible price both in terms of economy and of social interferences. In order to arrive to a sensible risk management framework, all major events, technical, managerial and official interventions need to be rated and weighed in a complex way by uncovering their interactions and the harmful effects resulting from both the neglect and the exaggeration of them. Without going into the deeper scientific details, we will review the social and health benefits, the categories of health risks and the actions and efforts (or the lack of them) made by the participants of the pools and spa scene. We will also try to call the attention to the dark areas in the overall knowledge and regulation of the scene and present proposals how to proceed in a harmonic way with the informed co-operation of the above mentioned participants. We need to look into issues of the skill and conscience of the service providers of all segments in the life-cycle of a pool and spa establishment, of the role and responsibility of the bathers as both the main sources and the victims of the health risks and of the sound approach to the evidence-based regulation and supervision.

2-IV THE STUDY OF SPECIFIC REACTIVITY OF H_2S IN THERMAL SPRING WATER

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Hydrogen Sulfide (H_2S) is a molecule dissolved in many thermal spring waters at variable concentration. These waters are widely adopted in recreational pools but there are concerns on the right disinfection methods to be adopted. In particular, the use of sulfur spring waters in pools prevents the normal techniques of disinfection with oxidant agents. Chlorine is often employed as disinfectant agent in recreation and swimming pools. Due to its high redox potential, Cl_2 has poor selective properties, cannot be used in thermal water containing H_2S and can produce collateral effects. Authors have recently proved that waters with high H_2S concentration present inhibition properties on some microbial species. This observation has opened up new perspectives for the use of H_2S as disinfectant in pool treatment and management. It remains unclear how H_2S exerts its bactericidal activity. In fact, as H_2S is a very weak acid, the variability in pH can cause changes in its reactivity in water and the conversion of sulfides can produce by-products with bactericidal/bacteriostatic effect. Some of these mechanisms are present in nature and were described. However, the behavior of H_2S in recreational waters has never been investigated. In order to clarify this point, a partial list of organic compounds present in recreational waters has been investigated for its reactivity with hydrogen sulfide in different chemical (pH) and physical condition (temperature). The list included aminoacids, lipids, monosaccarides, but also macromolecules like peptidoglycan (murein), keratin, polysaccharides (with different glycosidic bonds), agar (polygalactose sulphate). The reducing property of hydrogen sulfide on specific organic molecules can explain its bactericidal activity in recreational waters.

3-IV DROWNING AND NEAR-DROWNING IN SWIMMING POOLS IN ITALY: EPIDEMIOLOGICAL DATA DERIVED FROM THE PUBLIC PRESS IN 2008-2012

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Drowning is the process of experiencing respiratory impairment from submersion/immersion in liquid; outcomes are classified as death, morbidity and no morbidity. In most of the developed countries, drowning is the second or third cause of accidental death for children aged <15 and, according to the World Health Organization, the third leading cause of death in children aged 1-5 years. Males are especially at risk of drowning, with twice the overall mortality rate of females. In order to analyse accidents occurring in swimming pools, Italian websites and newspaper were browsed for the period January 2008-December 2012. A search was performed using the web-search engine Google and the keywords "Drowning" and "Near-drowning". The recorded events were split up for geographical location of the sport facility, age and gender of the injured subject, cause of the event and assistance received. Chi-square test was used to compare data by gender. The analyses were performed using the statistical software STATA 9.2. Data on 198 events were collected corresponding to an average of *ca.* 40 events/year. 67% of accidents were related to children aged 0-15 years. Our results confirms a higher incidence (87%) in summer, however this might be due not only to the higher number of people attending the swimming pools in that season, but also to the higher sensibility of the media in such period for this type of accidents. The same can be applied when the geographical area is considered: the higher number of accidents occurred in the North can be related both to a greater diffusion of swimming pools in these regions and to a higher sensibility of the media of these regions to the theme. In agreement with the international literature, males are more likely to drown than females. This is generally attributed to higher exposure to aquatic environment and riskier behaviour such as swimming alone, drinking alcohol before swimming alone and boating. The "≤4" and "5-15" age classes are those at highest risk because of their lower ability in swimming (baby) and of their tendency to behave inappropriately (children). Most of the accidents that didn't receive any kind of assistance (64%) occurred in domestic pools where the highest mortality rate (42%) was measured. For this kind of pools lifeguard assistance was never provided. Most of drownings occurring in swimming pools in Italy involve children aged <15 and are a public health problem that might be prevented if correct strategies would be adopted by decision-makers. This is the first study performed in Italy that analyses data concerning drownings occurred in swimming pools and stratifies them for place and month of occurrence, age and gender of the subjects involved as well as cause leading to the accident.

4-IV INTERACTION OF WATER WITH ADVANCED MATERIALS FOR SWIMMING POOL SPORTSWEAR BY NMR SPECTROSCOPY

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During 2009 FINA World Aquatics Championships high-tech swimsuits were used to add buoyancy, stability, speed and endurance. Engineered materials implemented records, but a controversy on swimsuits raised, as a kind of sportswear mediated doping. The design of a material must meet several requirements. In particular, it is of crucial importance the in-depth investigation of the chemical and physical characteristics of the material itself, as this knowledge can provide a deeper understanding of the main factors that will determine the materials effectiveness, allowing optimization of their design with specific attention to chemical and mechanical characteristics. In particular, data relating to the mobility of water molecules adsorbed by a polymer network are of crucial importance in view of the understanding of the properties of the material since they are related to interactions between the fluid medium and macromolecules. Among the techniques used to investigate the hydrodynamic, nuclear magnetic resonance has proven to be the election spectroscopy. The three-dimensional network of a polymer can be studied by means of the use of NMR techniques at high and low resolution in order to understand the molecular motions, the mobility of segments of the polymer and of the solvent molecules within the structure, in order to better interpret the kinetics of swelling and shrinkage of the macromolecule. With mono and two-dimensional high-resolution NMR techniques it is possible to characterize a polymer from a structural point of view while with NMR techniques in low resolution it is possible, through the measurement of transverse relaxation times (T_2) of H_2O, to evaluate the partitioning of the polymer matrix and, when these measures are carried out as a function of temperature, to obtain information on the exchange kinetic constants (K_b) between the H_2O protons and those of the chains of the polymer. Moreover the mobility of the system can be assessed through measures of autodiffusion coefficients (D) since this parameter might affect the effectiveness of the material. In the present study, materials supplied by the firm Okeo, consisting of polyamide and elastane in different percentages, were examined. Water with different types of mobility and different diffusion characteristics were measured on the basis of NMR relaxation times. The measurement of the longitudinal relaxation times have been performed with the sequence Inversion Recovery, the of the transverse relaxation time ones with the sequence Carr Purcell Meiboom Gill and the autodiffusion coefficients with the technique PFG-Multi Spin Echo. In this way we have obtained information on the water molecules dynamics, on the kinetics of diffusion and chemical exchanges and on the morphology of the analyzed sample.

5-IV THE ROLE OF AUTO-CONTROL FOR SAFE AND HEALTHY USE OF SWIMMING POOLS IN ITALY

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In 2003, the Italian Ministry of Health, with the technical support of the National Institute of Health in Italy, ISS, the National Olympic Committee and representatives of the Italian Regions, issued a new Italian regulatory guideline on *Hygienic aspects for the construction, maintaining and control of swimming pools*. The checks to verify the correct functioning of the swimming facilities are divided into external controls of competency of the Local Health Authority that supervises the correct management in hygienic safety of the implants, and internal controls of competency of the manager of the pool. Actually, an innovative element of the Agreement involves the designing and implementation of an internal auto-control plan, implemented by the organization's structure under the direct responsibility of the administrator of the facility. The auto-control plan should be specifically tailored to the single pool configuration and related facilities. It consists of a series of operating procedures, modulated on the basis of the specific characteristics of the plant and the process and scheduled with a specific frequency, aimed to monitor and maintain safety and hygiene in the swimming pool to minimize possible negative health impacts. As part of the system, a recording documentation is required to the administrator of each single facility containing objective evidence which shows how well activities are being performed and results are being achieved; it includes procedures of good practice, hygienic quality controls, critical points and identification/assessment of potential risks. The introduced innovation gives a precise responsibility to the pool manager who must consider other than the usual hygiene aspects, also all the other ones that may directly or indirectly influence on the health of people who transit in the pool. Self-control represents the main instrument of prevention to be applied as it leaves the right to the manager to manage autonomously the controls but it obligates him to guarantee the protection of health. Self-control must be essential, specific, dynamic and documented. And it must include:

- Identification of potential risk; a description of the main hazards based on Risk assessment/Risk management criteria are required together with safe operating procedures and corrective actions to be adopted.
- Specifics of the pool, including dimensions and depths, features and equipment and a plan of the whole facility with the details of technological systems.
- Communication to the public; arrangements for communicating safety messages to customers, ensuring maximum bather numbers are not exceeded, customer care and poolside rules.
- Water quality monitoring, including how often, how and where samples have to be taken, details of the operational and critical limits and actions to be taken if water

quality is not satisfactory.

- Recording of the results of the analytical controls of the parameters.
- Detailed work instructions, including pool cleaning procedures, safe setting up and checking of equipments.

This methodology aims to act before the dangers occur and it offers the following advantages:

- awareness of the state of structures and technological implants;
- professional development and staff involvement;
- preventive approach;
- a higher assurance of health security for the users.

6-IV HEALTH ENHANCING PHYSICAL ACTIVITY IN WATER

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During the last fifty years the epidemiological scenario showed a decrease in the relevance of infectious diseases respect to the diffusion of chronic degenerative diseases associated with the average lifespan. World Health Organization reports that chronic-diseases are the leading cause of mortality in the world, representing 63% of all deaths. In 2008 36 million of people died, of which 9 million were under 60 years old and 90% of these premature deaths occurred in low-and middle-income countries. Considering the aging of population, the prevention of cardiovascular, metabolic and musculoskeletal diseases, is becoming the primary objective to be achieved to enable the population to obtain and maintain a good quality of life. Physical activity in association to an appropriate diet, abstain from smoking and alcohol, is considered by WHO a main preventive factor. At least thirty minutes a day for three to five days a week of moderate aerobic physical activity (between 40-60% HR reserve; 55-70% HR max; 45-60% VO_{2max}; 4-6 METs/middle aged or 3.2-4.7METs/old age) will provide benefits to skeletal, muscular, cardiovascular, metabolic and mental health. At the same time, physical inactivity and low level of cardio-respiratory fitness represent modifiable risk factors. Thus the scientific community has focused attention to the analysis of different types of adapted physical activity specific to each pathological condition. Various studies confirm that aerobic physical activity in water (almost two and half hours per week) can decrease the risk of chronic illnesses. The benefits of the Adapted Physical Activity (APA) in water have led to the development of numerous aquatic disciplines aiming to both preventive and therapeutic; swimming, running, bycicling, aquagym, aquawalking, aquastreatching and aquaChi represent just few examples of the above mentioned disciplines. These activities, by exploiting the properties of water and the absence of gravity, allow to avoid the overloading of the joints and promote feelings of well-being linked to myo-relaxing activity of water, plus the thermoregulatory effect mediated by the acquatic environment, water properties, heat diffusion by convection, or the increased perception of security from falls especially for elderly people. It has been noted that inactive people have about double the risk of death if compared to swimmers. People report enjoying water-based exercise more than exercising on land; moreover, they can also exercise longer in water than on land without increased effort or joint or muscle pain. The purpose of this study was to evaluate, through an analysis of the publications on Medline database, from 1950 to 2012, the attention dedicated by the scientific community to the role of Preventive and APA in water in prevention of chronic diseases in particular: osteoporosis, osteoarthritis, obesity; and in the promotion of musculoskeletal health considering issues related to mechanical load due to excess of weight. From the results can be noted that since the 80's there was an increase in the number of studies that had as subject the association between recreational water activities and multifactorial diseases. At the same time, despite the increased interest in physical activity in general has grown exponentially, the APA in water still holds a marginal role. The contribute of water is not only related to the contrast to gravity and movement conditions, but also to activity on metabolism and microcirculation. The analysis of scientific evidences also dedicated to the interaction between environmental, genetic and behavioral risk factors, and the role of APA in water, allowed the definition of technical hints useful in the development of integrated prevention actions including screening and health education campaigns in structures for sport and physical activity where swimming pools are available.

7-IV THE ROLE OF PREVENTION TECHNICIAN IN SWIMMING POOL AND SPA, AS WORKPLACE: COMPARISON OF EDUCATION PROGRAMS

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Spas and swimming pools are workplaces that employ many workers with different tasks and exposed to diverse risk situations. Regulations related to safety, prevention and management of emergencies in the workplace can impact workers and professionals, operating in pools. New professional profiles, with scientific and technical expertise in risk management and prevention have been recently instituted in several countries. Well-qualified occupational health and safety professionals, expert in environmental sampling, new technological laboratory tools, data analysis are needed for leading an effective management of risk situations. In order to understand how occupational health and safety professionals are specifically formed for the needs of swimming pools and Spas, course lists and education programs have been compared from several Universities in Europe and outside Europe. In Italy the specific curriculum is under the name of TPALL - "tecnico prevenzione ambiente e luoghi di lavoro" (technician of prevention in environment and working places). Collected data clearly show the presence of a strong background in the physical, behavioral, psychosocial and life sciences. Special emphasis is dedicated to chemical, physical, mechanical and biological hazards. The description of specific issues connected to swimming pools and similar environments seems under represented, in comparison to others workplaces (*e.g.* mining, building, heavy industry). Some course lists present teaching module in Microbial Technology, particular useful in providing innovative tools for the monitoring, easily applicable to swimming pools environments.

8-IV RESTORATION OF RECREATIONAL WATER ARCHITECTURE: AN HISTORICAL EXCURSUS FROM ANCIENT SPA TO MODERN SWIMMING POOLS

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The recreational use of water has an old and important tradition in the history of society, hygiene and architecture. The oldest known swimming pool was described in the Gospel, and is the Siloe pool. However, the old societies had an intense use of water for recreational purposes. The same Romans, built “Thermae” in all the empire, exploiting the natural properties of local springs. In an historical excursus the importance of “Thermae” and swimming pools accompanied civilization and technological progress. Here, a description of peculiar cases important for architecture and water use are reported within the last two millennium, and showing the advanced modern period and perspectives for the next years. Between renaissance and Baroque period water assumes also an aesthetic role within the “triade”: architecture, green,water, further improving the wellness role of water in a new and integrated view. A spectacular use of water can be observed in Versailles in France, or Schonbrunn in Austria, or Villa d’Este in Tivoli, Italy. In the last centuries, the cult of the thermal vacation and “sanatorium” diffused in Europe, not only for the high society. Some examples include Baden Baden in Germany, Gellert in Hungary, Villa Igea in Palermo by Ernesto Basile, and several others. Today, an explosion of new uses for ancient buildings as well as de novo advanced buildings for swimming pools and wellness centres is diffusing all over the world. The technical management of waters within the different architectures is reported and described with pictures and authentic iconographic documents.

9-IV HUMAN BODY POSTURIZER: PRELIMINARY APPLICATION IN THE WATER SPORTS

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The Human Body Posturizer (HBP) is a modular system that allows to organize the body structures of the backs to optimize the postural dynamics. This system has been widely evaluated in terms of therapeutic application in different postural diseases, providing positive results both during the day-to-day activity and during the sport practice. The objective of the present preliminary study is to evaluate its functionality in the water sports testing the portability of this system during different activity. Five subject have worn the HBP in water both during walking and swimming for 15 minutes. After the test with HBP a questionnaire has been submitted to the subject to evaluate the portability of the system and the comfort during the movements. All the subject stated an high portability during walking and swimming. Furthermore they were able to perform all the movement during swimming. Although the application of the HBP in water have to be considered as preliminary the first results of the present analysis suggest the possibility to test this system as a therapeutic tool in water.

POSTER - SESSION V

1-V REMOVAL EFFICIENCY OF ANTHROPOGENIC POLLUTANTS IN DIFFERENT POOL WATER TREATMENT STEPS

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Swimming pool water contains many different pollutants from anthropogenic origin. Combined with chlorination, these pollutants can lead to the formation of Disinfection By-Products (DBP). As some DBP are irritating to the skin, eyes or respiratory tract, formation of DBP should be minimized. Reduction of DBP-formation can be achieved by reduction of anthropogenic pollutants. Different treatment steps can be used to reduce anthropogenic pollutants. The objective of this study was to determine the removal efficiency of different anthropogenic pollutants in different pool water treatment steps. Two lab-scaled pilot plants, of 1 m^3/h each, were used for this study. The treatment steps studied in these experiments are: sand filtration, biological filtration and ultra filtration. Also two types of disinfection were studied, chlorination and UV-treatment. Single experiments were continued for 3-4 weeks to ensure sufficient time for biofilm development in the biological filters. Non chlorinated tap water was used as feed water for the experiments. After heating and pH correction, a Body Fluid Analogue (BFA) was added to simulate anthropogenic pollutants. Although real anthropogenic pollutants from swimmers contain more carbon components then nitrogen components (by weight), the usage of suchlike BFA lead to blocking of the sand filters within hours after starting an experiment. To avoid blocking of the sand filters, the composition of the BFA was changed. The main components used in the BFA were: urea, sodium citrate and creatine monohydrate. Addition of dipotassium phosphate was needed as a trace element to ensure bioactivity. The experiments were done at different temperatures and different BFA concentrations. The removal efficiency was determined by analysing water quality parameters (total organic carbon, total nitrogen, ammonium, urea, nitrate, oxygen, pH, ATP and total cell count) before and after each treatment step. The results show that the removal efficiency was found to be the lowest when sand filtration combined with chlorination was used. The presence of chlorine based products did not avoid the formation of bioactivity in the sand filter. The highest removal efficiency was found when biological filtration combined with ultrafiltration was used.

2-V EFFECTS OF UV-DECHLORAMINATION OF SWIMMING POOL WATER ON THE FORMATION OF DISINFECTION BY-PRODUCTS: A LAB-SCALE STUDY

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UV dechloramination has become a very popular process for reducing the concentration of chloramines in public swimming pool water. As the effects of this process on the formation of Disinfection By-Products (DBPs) remain a controversial issue, a bench-scale study has been undertaken to examine the impact of UV dechloramination on the formation of various DBPs. THMs were analyzed by the headspace technique combined with GC-MS. HANs, CH, DCP, TCP and TCNM were determined after liquid-liquid extraction by GC according to the USEPA Method 551.1. Haloacetic Acids (HAAs) were determined according to the USEPA Method 552.2. Four pool water samples were exposed to UV radiation at 254 nm in the presence of free chlorine ($[Cl_2]_0$=3 mg/L) and then chlorinated in the dark for 24 h ($[Cl_2]_0$=3 mg/L). High UV doses (up to 47 kJ/m^2) were used to simulate cumulative UV doses received by real pool waters (50-70 kJ/m^2 with a mean residence time of water in the pool of 5-7 days). The data showed that UV irradiation led to a 90% photodecay of free chlorine for UV doses ranging from 13 to 20 kJ/m^2. Photodecay of free chlorine observed at the lab scale was consistent with full-scale data obtained in a swimming-pool equipped with a UV reactor where an overconsumption of chlorine (+30%) was observed. Moreover, UV exposure leads to a significant increase in the chlorine demand of pool water during the post chlorination step. The percentages of increase in the chlorine demand (non-exposed sample *vs* UV-exposed sample) ranges from +50% to +620%. Our data also demonstrate that UV dechloramination of swimming pool water would increase the chlorine consumption by two main ways: direct photolysis reactions of free chlorine in the UV chamber and increase in the chlorine demand of the pool water. Ionic chromatography analyses demonstrated that the photodecomposition of free chlorine in ultra-pure water leads only to the production of chloride and chlorate ions as stable photo-products. The production of chlorate in ultra-pure water was approximately 0.09 mole of chlorate/mole of chlorine photodecomposed (≈0.13 mg ClO_3^- formed/mg Cl_2 decomposed). Yields ranging from 0.05 to 0.11 mol ClO_3^-/mol Cl_2 decomposed were obtained from experiments performed with tap water and with pool water samples. The effect effect of UV on the formation of various disinfection by-products has been evaluated; UV exposure followed by post-chlorination did not significantly affect the formation of haloacetic acids, led to a small increase (less than +20%) in the concentrations of total organic halogen (AOX) and of chloral hydrate which is one of the most abundant DBP in swimming pool waters (17,9±5,5% of the AOX). The formation of trihalomethanes (chloroform-TCM, bromodichloromethane-BDCM, chlorodibromomethane-CDBM) was

very impacted by UV exposure prior to the post chlorination step with an increasing of 204 ±44% of the total amount of THM. Interestingly the increases in the concentrations of BDCM and DBCM were higher than those obtained for TCM but the concentrations levels of BDCM and DBCM are much lower that the concentrations of TCM. On the contrary, the UV treatment reduced the formation of bromoform. As for THM Halonitromethane (HAN) formation was promoted by UV exposure, where an increasing of +219 ±56% and +228 ±67% was observed for dichloroacetonitrile and bromochloroacetonitrile, respectively. This laboratory-scale study demonstrates that UV dechloramination of swimming pool water by low pressure UV lamps and at UV doses similar to those usually applied for real pool water (cumulative UV doses up to 50 kJ/m^2 and presence of free chlorine) significantly increases the chlorine demand of pool waters and the formation of some DBPs (more particularly TCM, BDCM, CDBM, DCAN, TCP and TCNM) during the post-chlorination step. All these data was confirmed by our full-scale studies because similar trends were obtained for the effects of UV dechloramination by medium pressure UV dechloraminator on the chlorine consumption and on the formation of DBPs.

3-V SURVEILLANCE OF SWIMMING POOL WATER QUALITY MONITORING RESULTS IN UK POOLS

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Chemical and bacteriological swimming pool water quality in the UK is monitored in accordance with the guidelines produced by the Pool Water Treatment Advisory Group (PWTAG). Pool operators are required to routinely test pool water for residual disinfectant and a variety of other parameters to ensure that satisfactory conditions are being maintained, and to employ the services of an independent specialist to monitor the bacteriological quality of the pool water. To date within the UK and the US there has been a historical reliance on chlorinating bathing water as a primary means of controlling water quality and the potential risk of infection. Reliance on chlorine residuals in bathing water and the potential health implications has been the topic of much debate. Although the use of chlorine in pool water has recognized potentially adverse side effects on human health, chlorine remains an effective disinfectant and the primary means of disinfecting pool water in the UK. The objective of this paper is to examine how bacteriological water quality is affected by specific operational control parameters observed in swimming pools including residual disinfectant concentration, and whether the chemical control parameters currently used to determine whether a pool is satisfactory for bather use in the UK correlate with satisfactory bacteriological results following laboratory analysis. Results of this surveillance exercise will be used to assist in determining whether the current control parameters adopted in the UK are considered appropriate for maintaining acceptable bathing water quality. Swimming pool monitoring results from a broad spectrum of public swimming pools have been collated and evaluated. Monitoring results of site chemical analysis including free chlorine concentration and results of microbial analysis for specific indicator organisms including *Pseudomonas aeruginosa* and *Escherichia coli* have been compared. Preliminary results indicate that for swimming pools operating in the UK, the current minimum operational parameters must be maintained if the risk of infection is to be adequately controlled. In conclusion, Swimming pool water quality is affected by several key factors. Principally, the competence of the pool operator and their implementation of an appropriate water treatment and maintenance regime, and also the bather load on the pool. While operational standards can be changed in order to maintain and improve bathing water quality, without the cooperation of the bather and significant improvements in bather's personal hygiene, results suggest that it is not appropriate to reduce the recommended minimum operational free chlorine concentration in pools operated within the UK.

4-V HYGIENIC SURVEILLANCE IN SWIMMING POOLS: MONITORING THE WATER QUALITY IN BOLOGNA FACILITIES IN THE PERIOD 2010-2012

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In Italy the hygienic characteristics of swimming pools are regulated by the *Accordo Stato Regioni e Province Autonome* 16 January 2003. The document sets out technical norms regarding hygiene-health aspects in the construction, maintenance and vigilance of swimming pools. It also provides a list of physical, chemical and microbiological parameters for the water, in each case indicating limits valid at national level regarding both the supply water and that of the pools. The Prevention Department of the Local Health Authorities (AUSLs) is responsible for such monitoring and may make use of Environmental Agencies (ARPA) for the chemical, physical and microbiological testing. In this context, the AUSL of Bologna, in the three-year period 2010-2012, monitored a total of 61 swimming pools (17 indoor, 34 outdoor, 10 in/outdoor) involving 809 water samples, 235 of supply water, 175 of water entering the pool and 399 of pool water. On average 3 and 1 samplings/year were respectively carried out for each indoor and outdoor facility. The samples of supply water always conformed to the chemical and microbiological limits established for drinking water by the Italian law D.Lgs 31 of 2001. The incoming water exceeded the microbiological limits in around 75% of samples (Total-Heterotrophic-Count, THC) 37°C: 73.8%; THC 22°C: 39.3%; Enterococci: 0.9%; *Ps.aeruginosa*: 25.2%). The pool water did not conform to the microbiological standards in around 17% of the samples (THC 37°C: 15.6%; THC 22°C: 6.6%; Enterococci: 0.9%; *Ps.aeruginosa*: 4.5%). In particular, 47.1% of the non-conforming samples involved more than one microbiological parameter, almost always THCs and *Ps.aeruginosa*. The microbiological non-conformity led to suspension of swimming activities only in an outdoor plant in summer 2010. Suspensions of the swimming activities were necessary for incongruities in the chemical parameters (pH<5; residual chlorine >5mg/L; oxygen demand>3mg/L) in 1.64% of the pool water samples and always in outdoor swimming-pools. In the other cases warning letter invited the operators to perform the corrective measures previously established in the plan of risk assessment of the facility. The three-year period of monitoring highlights certain critical areas: 1) the high level of contamination from THCs and *Ps.aeruginosa* (1-300 cfu/100mL) in the incoming water, compared with the pool water, and therefore pointing to an incorrect technological management of the plant; 2) the more problematic management of chemical parameters (pH, residual chlorine, suspended solids) in outdoor swimming pools. However, a more positive aspect is the almost total absence of microorganisms of fecal origin.

5-V SURVELLIANCE OF SWIMMING POOL AND SPA IN MONTENEGRO

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Considering the fact that Montenegro is a tourist country and that it is visited by about 1.2 million tourists annually, who mainly use the hotel accommodation, quality of pool and spa water is one of the crucial issues in the health care system, for both guests and the domestic population. The existing legislation in Montenegro has not adequately recognized or defined importance of quality control of pool and spa water. At the end of 2009 the draft version of Regulation on the minimum sanitary and other requirements for swimming pool water has been prepared. This Regulation defines the minimum hygiene requirements, which must be met for bathing pool water, the way of their establishing and monitoring conditions for the provision of hygienic requirements for swimming pool water. Indicated Regulation included only the pool water quality while air quality (indoor pools) has not been taken into account. Despite the fact that issue of pool and spa water quality is not covered by legislation, Montenegro has recognized the health importance and hazards that may cause many diseases transmitted via water, with special emphasis on vulnerable populations. This problem has been solved through assessing the quality of pool and spa water in accordance to the applicable Regulation for hygienic safety of drinking water that does not completely comply with the Directive on drinking water 98/83. As the quality control of these waters is not obligatory, the percentage of analyzed water samples is very small, almost alarming, relying on the consciousness of individual owners and managers of pools. According to official data, the tourist organization of Montenegro has 1644 hotels and apartments out of which 300 have pools and/or spa centers, where supervision is conducted in less than 5% of above mentioned pools. Monitoring of the pool and spa water quality in Montenegro is done by laboratories (chemical and microbiological) within health care institutions, i.e. the Institute of Public Health and Primary Health Care Center in Bar. These laboratories employ specialists of sanitary chemistry and microbiology, while doctors- specialist of hygiene, give final conclusion on health impact assessment of analyzed water. Technical capacity of these laboratories is not at a satisfactory level, especially laboratories in the Primary Health Care Center in Bar. Therefore it is necessary to make a National Regulation according to the recommendations contained in the "Guidelines for safe recreational-water environments" produced by World Health Organization which would ensure a good and steady pool water quality in terms of hygiene, safety and aesthetics and thus exclude any adverse impact the human's health, particularly in relation to the causes of diseases, and to make positive progress in the promotion of tourism in terms of security in which the swimming pool and spa centers have become an indispensable part. Until Montenegro has not received such a document we can only raise awareness of the owner or the manager of the pools and spas, and the general population about the importance of safe health pool and spa water and how to use them.

6-V WATER QUALITY ASSESSMENT AND MANAGEMENT IN SPA

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Swimming pool and spa disinfection is generally a good procedure for killing microorganisms that are free floating in the water. However, this practice is surely not effective in getting down the slime layers of biofilm on surfaces and kill all potentially harmful organisms. Biofilm is one of the most significant overlooked phenomenon in these structures. It is very hard to remove with traditional cleaning chemicals and biocides, currently showing several limitations. A study was conducted in a spa located in a big hotel in Rome, Italy, with the aim to overcome biofilm control problems and assure a good water management. Two times a week, a pool is shut down, drained, cleaned and refilled. New water is submitted to a shock chlorination. Recently, an innovative hygienic practice, successfully applied in several food and beverage plants, was introduced. It consists in a two-step cleaning procedure comprising a patented multi-enzyme mix followed by a disinfection step. The enzymes act specifically on the Extracellular Polymeric Substance (EPS) that forms the structure of the biofilm, degrading it and allowing the detergent to remove the biofilm. At different steps of the process the following parameters were monitored in water: HPC, bacterial indicators, staphylococci, *Pseudomonas aeruginosa,* Non-Tuberculous Mycobacteria (NTM), *Legionella*, enteric viruses (enterovirus, adenovirus, norovirus GI and biofilm GII), epitheliotropic viruses (papillomavirus) and free living amoebae. Miniaturized MPN methods (Colilert 18, Enterolert, Pseudalert) were used for enumeration of bacterial indicators and *P. aeruginosa;* culture methods were employed for HPC and staphylococci, while molecular methodologies were applied for NTM detection (PCR and RFLP) and for enteric and epitheliotropic viruses (nested PCR assays and DNA sequencing of PCR amplicons). Free living amoebae were detected by cultural methods and microscopic examination. ATP was measured in biofilm samples collected from pool surfaces. Analytical results obtained on pool water treated with enzymes showed increased microbial yields of HPC, coliforms, *P. aeruginosa,* staphylococci and NTM respect to the concentrations before the treatment (absence or very low counts of organisms). Significant densities of the same microbial parameters were also detected in water samples eluted from pool filters. Unlike, no release of faecal indicators, viruses and free living amoebae was observed in pool water after treatment with enzymes, nor in water from enzyme treated filters. In biofilm samples very high numbers of ATP were observed. Results obtained from water samples collected after a final disinfection step showed a very good microbial quality of pool water. This preliminary investigation seems to suggest that a good management of the spa could include additional treatments comprising a multi-enzyme cleaning procedure helpful in keeping biofilm under control.

7-V REAL-TIME MONITORING OF RECREATIONAL WATERS

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Today, swimming pool safety is assessed by time consuming analysis, performed in equipped laboratories by trained personnel. Briefly, after sampling the water, microbial or chemical test will provide an answer within a few days. During this window-time, water hygiene remains unknown and managers, users or public health authorities need to wait before taking further prevention decisions. Presently, no tool is available to know the quality and safety of the water "in the pool", in "real-time". Independently from standard disinfection procedures or traditional periodic analysis, modern water surveillance deserves further advances. Several critical situations such as pool overcrowding, plant malfunction or misuse, or accidental fecal release can determine serious outbreaks. Immediate detection of water contamination by Swimming Pool Real-Time Monitoring Systems (SP-RTMS) can protect the growing number of users involved in aquatic sport competitions, adapted physical activity, recreation or rehabilitation in water. To survey quality and safety of recreational waters in real-time, the SP-RTMS prototype (patent pending) was developed allowing monitoring and generation of alarm signals from prompt response actions. The general principle and method is not based on pathogen or hazard search, but on innovative hygiene markers identified using a metabolomic approach. Detection of sensitive and specific indicators was implemented in an automated device, that leads water sampling and carry out the reactions. Engineered sensors were realized to identify the selected markers by colorimetric reactions. Data acquisition is analyzed by algorithms through a dedicated software. The prototype system can be installed in any pool plant and a monitor will report the results of the water in that instant. A software-driven system can automatically manage immediate corrective actions, such as disinfection, circulation, alerts, or simply reporting on a screen in the pool (or on an mobile phone) the quality of the water in that moment, *e.g.* by the threshold graphic or by a color code semaphore. In conclusion, an innovative system for managing swimming pool surveillance is reported. It supports analysis of organic contamination by a strategy that is complementary to the classical time consuming culture of microrganisms. Its applications can flank and implement the already available and established traditional approaches, improving prevention with promising perspectives.

8-V EMERGING ISSUES ON DEGRADATION BY-PRODUCTS DERIVING FROM PERSONAL CARE PRODUCTS AND PHARMACEUTICALS DURING DISINFECTION PROCESSES OF WATER USED IN SWIMMING POOLS

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The use of disinfection substances in the sanitation processes of artificial water used for sports amenities and swimming pools has recently raised some serious concerns. The adverse effects of disinfection processes on traditional organic pollutants dissolved in raw, drinking and waste waters had already been identified and studied and adequate countermeasures aimed at avoiding consumers' exposure to harmful chlorinated byproducts, such as trihalomethanes, haloacetic acids and chlorophenols, had been long since adopted, in particular also by means of technical provisions, *e.g.*, as those developed by WHO, and by national legislative actions. On the other hand, the assessment of the impact of chlorination and other disinfection techniques in pool waters and artificial water bodies on chemicals released by bathers, due to Personal Care Products (PPCPs) and Pharmaceuticals (PHARM) is still in progress. Studies on the consequences of chlorinated and oxidized by-products of PPCPs and PHARM on occasional or professional bathers are even more lacking. It has been demonstrated that the high reactivity of common disinfection agents, such as chlorine, chloramine, ozone and UV radiation, can lead to the formation of undesirable chlorinated and oxidized compounds and of nitrosamine precursors from PHARM as well as from Sunscreens (SSCs) and other PPCPs. Moreover, the oxidizing effects of increasing concentrations of Cl atoms may lead to deep modifications of the molecular structures, *e.g.*, of $Al(OH)_3$ layers, commonly used in coating the core Ti-based nanoparticles employed in the formulation of commercial SSCs. The degradation of those Al layers may cause instability of the TiO_2 nanoparticles and the formation of harmful and complex mixtures of reactive O- species. The first symptoms of potential adverse health effects on humans should be promptly taken into consideration and investigated.

POSTER - SESSION VI

1-VI COMPUTATIONAL FLUID DYNAMICS IN SWIMMING POOLS

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Both the effective removal of pollutants from a swimming pool, and sufficient supply of a residual disinfectant, depends to a large extent on pool hydraulics and circulation. Although pool circulation is clearly important, it has shown to be difficult to effectively model these dynamics using conventional Computational Fluid Dynamics (CFD) techniques. In this work we present the first results with a particle-based CFD approach for pool circulation, and evaluate the merits and possible shortcomings of this alternative approach to pool modelling. In most conventional CFD models for pool circulation, the spatial domain is represented by a (fixed) mesh or grid on which flow velocities and fluid pressures are computed. Apart from the fact that discretizing the spatial domain can be complicated by the geometry of inflows and overflows, solving the governing equations on a fixed grid (Eulerian description) makes it fundamentally difficult to follow or track material properties transported by the flow. Although two-dimensional pool models have been successfully developed, three-dimensional CFD models for swimming pools appear not to have been reported thus far. In this work we will simulate the three-dimensional dynamics of a test pool using a Smoothed Particle Hydrodynamics (SPH) model. SPH is a mesh-free particle method, in which the Navier-Stokes equations are solved by representing the fluid as a large number of discrete particles. The size of the particles is much larger than that of water molecules but much smaller than the relevant length scales of the processes we wish to resolve. The smallest scale of the flow we wish to resolve thus dictates particle size, and SPH simulations are typically carried out with large quantities of particles. However, the structure of SPH can be exploited in parallelized computations on clusters of CPUs or GPUs so that computations can be performed with reasonable simulation times. Most importantly, a particle method like SPH is fundamentally Lagrangian, which implies that the history of each particle is directly known (important for instance residence time and particle tracking); further by lacking a mesh, an SPH model is capable of solving complex and dynamic geometries. This makes it easier to model overflow edges, pool inlets, and even moving objects in the pool basin.

2-VI REMOVAL OF DNP-PRECURSORS FROM A BODY FLUID ANALOGUE BY POWDERED ACTIVATED CARBON ADSORPTION

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During bathing, organic substances as part of urine, sweat, hair or skin-particles are introduced into the Swimming Pool Water (SPW). These substances may continuously react with chlorine, which results in the formation of Disinfection By-Products (DBPs). Concentrations of DBPs in swimming pool water shall be kept low as they can affect human health. In swimming pool water treatment, the application of Granular or Powdered Activated Carbon (GAC or PAC) is proven to lower DBP concentrations in the pool water. However, as DBPs are polar and hardly adsorbable on activated carbon, it is important to remove precursors as well. Powdered activated carbon processes include the dosage of PAC to the feed water as suspension, followed by deep bed filtration or membrane filtration to remove the loaded PAC. When combined with deep bed filtration, during a filtration cycle of up to several days, the amount of PAC in the system increases continuously. Also, when PAC is combined with membrane filtration such as Micro- or Ultrafiltration (MF or UF), it is added as suspension and retained by the membrane, forming a thin coating. In membrane filtration, a filtration cycle lasts a few hours only. As mostly the dosage of PAC is the same whether it is combined with deep bed or membrane filtration, on average the total amount of PAC in the system is much lower when combined with membranes. Yet there is no fundamental knowledge on the equilibria and the kinetics of DBP- or DBP-precursor-removal in pool water treatment. Consequently, the aim of this study was to investigate adsorption of DBP precursors from a body-fluid-analogue (BFA). For the experiments, a PAC commonly used in SPW treatment was used. Adsorption experiments were conducted using single substances of a well-defined body fluid analogue (BFA) which represents the typical bather load in SPW. Since also humic substances are dissolved in SPW, introduced by bathers or as dissolved in the filling water, the removal of DOC from a humic acid model solution was investigated in additional experiments. Both isotherms were determined and kinetics were studied. As can be concluded from the properties of BFA-components, two of them, i. e. urea and ammonia, are supposed to be hardly adsorbable. This was confirmed by the isotherm experiments. The remaining BFA-components reached adsorption equilibrium within ~60 s. Since in membrane applications PAC dosing is typically done with a hydraulic retention time of ~45 s before the membrane module, equilibrium between the adsorbed and dissolved phase will be reached when the PAC is retained by the membrane. However, the so-called filter effect has to be taken into account which allows much higher solid phase concentrations for AC in a filter layer when compared to a completely stirred tank. Furthermore, the removal of the halogenated species, formed by chlorination of the BFA substances, is currently investigated. Using the equilibrium and kinetic data from the lab-experiments, model-calculations show the effect of PAC-dosages and different filter retention times on DBP-precursor concentrations in swimming pools.

3-VI REMOVAL EFFECTIVITY OF A SILICON CARBIDE MICROFILTRATION MEMBRANE FOR PARTICLES IN SWIMMING POOL WATER

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Particles found in Swimming Pool Water (SPW) comprise a heterogeneous mixture of microorganisms and other organic and inorganic particles. They differ in size, shape, surface characteristics and health relevance. Microorganisms (MO) in SPW may attach to other particles present in swimming pool water leading to higher chlorine doses needed for inactivation. As the typical nominal cut-off of a ceramic microfiltration membrane is larger than viruses but smaller than most bacteria, it is interesting to evaluate the performance of a microfiltration membrane for MO and particle rejection. In this study the removal effectiveness of a new type of dead end silicon carbide membrane (300 nm cut off) used in SPW treatment was investigated in surrogate challenge tests using MS2 phages (~25 nm) and fluorescent microspheres in a size of 50 nm to 500 nm as model particles. In first series, the surrogates were suspended in deionized water. Thus, rejection mechanisms like the formation of a filter cake layer and agglomeration of the surrogates to other particles present in the feed-solution are excluded. In a second series the same experiments were performed with a surrogate suspension in SPW where the formation of a filter cake layer and agglomeration were respected. When using surrogate suspension in deionized water, the ceramic microfiltration membrane showed a surprisingly high removal rate for MS2 phages and 50 nm microspheres. Mainly hydrophobic interactions between the sub cut-off sized surrogates and the membrane surface are suggested to be responsible for the high log-removal. The rejection effectiveness of particles with a size in the same order of magnitude as the nominal membrane cut-off (300 nm and 500 nm microspheres) was smaller than expected. The passage of these particles through the membrane is explained by the presence of a few abnormal large pores in the heterogenic ceramic membrane surface. Experiments using surrogate suspensions in swimming pool water showed that the log-removal of the MS2 phages is much higher for the former. Attachment of the MS2 phages with particles present in the swimming pool water as well as cake layer formation on the membrane surface is suggested to be responsible for the increased virus rejection. When using 500 nm fluorescent microspheres the rejection was higher than in deionized water. Since the log-removal of 500 nm microspheres was time dependent, mainly blockage of the abnormal large pores in the heterogeneous ceramic membrane structure by particles present in SPW is suggested to be the main mechanism for the increasing log-removal. Concluding, the ceramic silicon carbide MF membranes removed almost all particles >1 µm present in SPW whereas it could be shown that particles in a size of 25 nm up to 500 nm may pass the heterogenic membrane structure.

4-VI ANALYSIS OF FLUID FLOW IN POOLS WITH HELP OF COMPUTATIONAL FLUID DYNAMICS

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Bathers introduce pollutants to swimming pools in dissolved and particulate form which have to be removed by treatment processes. In order to be removed they first have to be transported to the treatment. However, when the average residence time of the water in the pool is three to four hours, due to the hydraulics in the pool some volumes of contaminated water might stay longer or shorter. In order to optimize the system pool and treatment as a whole, a thorough understanding of the processes in the pool is necessary. These involve the flow fields in each section as well as chemical reactions (*e.g.* resulting in disinfection and in the formation of disinfection by-products as well) and physical processes like sedimentation. Computational Fluid Dynamics (CFD) has become a powerful tool to investigate flows with reactions and transport processes. For a full scale pool, a CFD model was set up. The model developed can describe the flow fields in the pool and can be used to study how these flow-fields are influenced by the positions and types of inflow nozzles. As for chemical reactions, the distributions of species produced as a function of time can be simulated. As bathers might accidentally release contaminants at different spots, it can be studied how these contaminants might react or how they will be transported out of the pool. Based on the model, the quality of the pool water can be modelled and analysed dynamically. During the study, positions or types of nozzles might be varied or different flow rates and treatment efficiencies studied. For a full scale pool a Computational Fluid Dynamics (CFD) model was set up. The model is currently validated by studying residence times of water in the pool. To do so, a traceable chemical is dosed in a short time. The concentration of the chemical in the inflow to the treatment train and at one or two positions in the pool is monitored using an online spectrophotometer. Finally, the concentration of the chemical is compared to the simulation and the model adjusted if necessary. After validation the CFD-model will be used to demonstrate how nozzle positions and treatment options can be optimized in order to minimize disinfection by-product concentrations and contaminants in the pool.

5-VI PHOTOLYTIC REMOVAL OF DBPs BY MEDIUM PRESSURE UV IN SWIMMING POOL WATER

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Medium pressure UV is used for controlling the concentration of combined chlorine (chloramines) in many public swimming pools. Little is known about the fate of other disinfection by-products (DBPs) in UV treatment. Photolysis by medium pressure UV treatment was investigated for 12 DBPs reported to be found in swimming pool water: chloroform, bromodichloromethane, dibromochloromethane, bromoform, dichloroacetonitrile, bromochloroacetonitrile, dibromoacetronitrile, trichloroacetonitrile, trichloronitromethane, dichloropropanone, trichloropropanone, and chloral hydrate. First order photolysis constants ranged 26-fold from 0.020 min^{-1} for chloroform to 0.523 min^{-1} for trichloronitromethane. The rate constants generally increased with bromine substitution. Using the UV removal of combined chlorine as an actinometer, the rate constants were recalculated to actual treatment doses of UV applied in a swimming pool. In an investigated public pool the UV dose was equivalent to an applied electrical energy of 1.34 kWh/m^{3}d and the UV dose required to removed 90% of trichloronitromethane was 0.4 kWh m^{-3} d^{-1}, while 2.6 kWh/m^{3}d^1 was required for chloral hydrate and the bromine containing haloacetonitriles and trihalomethanes ranged from 0.6 to 3.1 kWh/m^{3}d^1. It was predicted thus that a beneficial side-effect of applying UV for removing combined chlorine from the pool water could be a significant removal of trichloronitromethane, chloral hydrate and the bromine containing haloacetonitriles and trihalomethanes.

6-VI EVALUATION OF DISINFECTANT EFFICACY BY ULTRAVIOLET LIGHT IN A LABORATORY SWIMMING POOL MODEL

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Swimming pool water disinfection is essential in order to minimize the risk of microbiological hazards and to protect swimmers from infection. Traditionally, chlorine is used to disinfect swimming pools. However, it produces residual toxic compounds such as trihalomethanes, halogenic acetic acids, haloacetonnitrils which are toxic for the bather's health. An alternative, promising and environmentally friendly disinfection method is the use of UV light. Using UV for disinfection lowers the chemical cost and usage, provides instantaneous disinfection (chemicals require a residence time), lowers disinfection by-products and provide for less intensive maintenance. It generally creates a healthier swim environment for the bathers. The aim of this study was to assess the effect of disinfection of different microorganisms with the use of UV-C light using a swimming pool lab model which simulated the conditions of an actual swimming pool and. The pool model simulated an actual swimming pool of Olympics' dimensions and was constructed from Plexiglas material in scale 1:250. The tank dimensions were (33x25x2) cm and the maximum capacity was 58 l. The circulating water system with an enclosed U.V treatment apparatus (10W lamp) was used. The lamp had a maximum capacity of water purification of 500 ltr/h. A peristaltic pump circulated water at a flow rate of 18l/h. A thermostat was put in the centre of the pool model and adjusted the temperature at 25°C. The bacterial strains that were used were *Escherichia coli* NCTC 9001, *Enterobacter aerogenes* NCTC 10006, *Staphylococus aureus* NCTC 6571 and *Pseudomonas aeruginosa* NCTC 10662. *Ps.aeruginosa* is an opportunistic bacterium which can accumulate in biofilms and it is very common causing infection problems in swimming pools. *S. aureus* has been used as it is a pathogen causing several health problems. *E. coli* and *E. aerogenes* have been used as they are indicators of water quality. The water recirculation was completed in 2.5 hours. After a zero time, sample was obtained, the UV light was turned on and samples were obtained at different time intervals (up to 9 hours) for 2 consecutive days. The reduction of all the microorganisms was effective and reached up to 1-3 logs after 6 hours of continuing UV disinfection apart from *Ps.aeruginosa* which didn't show significant reduction. The data obtained during this study suggested that u.v. disinfection can effectively reduce or eliminate bacteria existing in circulating water systems, thus reducing problems concerning public health and creating a healthier environment for the bathers.

7-VI WATER TREATMENT IN FLOATING POOLS

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Salt is an essential mineral for the human organism, its effect on skin has long been known and documented. The Greek physician and scientist Hippocrates described the healing properties of sea water on various diseases more than 2000 years ago. Salt water was used for baths, steam inhalations and for the treatment of gout, rheumatic and skin diseases. Therefore, it is not surprising that salt treatment has found its way into therapy pools, but also into many spa establishments and wellness-areas of hotels. An extended usage of salt water pools, where in addition to the positive properties of the salt, absolute peace and total relaxation is added, is floating. Floating means that people are kept virtually weightless on the water surface with the help of concentrated salt water in special floating pools. The aim of floating is a deep relaxation in the complete absence of external stimuli. Stress reduction, wellness and an experience factor is added to the medical effect of salt treatment. Since floating pools, just as normal public pools, are usually used by a diverse mix of people, special attention must also be given to hygiene. This means, a floating pool must, similar to a whirlpool, be emptied and cleaned at least daily. Constant concern must be given to the compliance with the hygiene parameters and a proper water treatment must be guaranteed etc. The hygiene requirements, as in the standard DIN 19643, should generally apply also in floating pools. The nature of floating pools shows that the water treatment differs from the usual treatment. On one hand, the water can only be treated in a batch mode due to the complete rest of the treatment during the floating service, which means a complete lack of pool hydraulics. As there is currently no applicable standard for floating pool water and the requirements in DIN 19643 cannot be fully fulfilled, the question arises of how floating pool water should be treated. Current practices on the market do not reflect the hygienic needs. Do human pathogenic germs survive in high concentrated brines? Which requirements must be met by the disinfectant? How are the corresponding parameters measured? Are the currently used methods applicable to such high concentrations of salt at all? A study has been carried out by the author, which attempts to answer some of the questions. The investigation has shown that with a specific technology, water quality criteria defined according to the hygiene requirements of the DIN 19643 can be permanently achieved, at the same time allowing a cost efficient operation. Currently, a task force within the German Society for the Swimming Pool Industry (Deutsche Gesellschaft für das Badewesen) with the participation of the author is working on a code of practice on this topic. The test results obtained in this study as well as field experiences are considered and further investigations are pursued.

8-VI WHAT ABOUT BEHAVIOURS IN SWIMMING POOLS? RESULTS OF AN ITALIAN MULTICENTRE STUDY

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Background. Swimming is acknowledged as one of the most beneficial forms of exercise and is also an important rehabilitation therapy. Swimming pools, however, can expose people to a variety of health risks associated with physical, microbial and chemical hazards. WHO guidelines for safe recreational water environments (2006) provide recommendations on personal hygiene as a fundamental means to reduce the biological and chemical contamination of water and to maintain the water clean. No relevant studies have been performed to assess the actual compliance with hygiene-related rules in swimming pools. In order to increase the awareness on this topic, we performed a study on the behaviour of indoor swimming pool users in five Italian cities. We analyzed the variables associated with incorrect behaviours and evaluated users' recognition of the importance of complying with swimming pool rules.

Methods. A cross sectional study was carried out. A self-administered questionnaire was used to collect data from swimming pool users. The association between specific variables and patterns of behaviours was assessed, focussing especially on lack of showering. A p value <0.05 was considered statistically significant.

Results. A total of 4356 questionnaires were analyzed (91.7% response rate). Results regarding the compliance with the pre-swim shower rule appear to be particularly interesting. Sixty-five percent of interviewees reported they always shower before entering the pool. The main reasons for doing so were "to wash oneself" (50.5%) and "to get used to the temperature of the water" (44.3%), with 5.2% answering "for both reasons". The risk factors showing a significant association with lack of showering were: female sex (OR=1.37, 95% CI: 1.2-1.59); age of 14-17 years (OR=5.09, 95% CI: 3.40-7.64); not reading the pool rules (OR=1.24, 95% CI: 1.10-1.41); living in Central Italy (OR=3.3, 95% CI: 2.65-4.1) or Southern Italy (OR=1.35, 95% CI: 1.18-1.55); and having attended a swimming course (OR=1.7, 95% CI: 1.48-1.97).

Conclusions. Results reveal that incorrect behaviours are widespread among swimming pool users and that there is little awareness of the importance of following pool rules for reducing the risks associated with biological, physical and chemical hazards. More attention should be given to health promotion in swimming facilities. Moreover, it is necessary to

indicate clearly what the best practices are. Targeted educational interventions should aim at making bathers aware that in swimming pools, more than in other environments, their and other people's well-being depends on following correct behaviours.

9-VI MOVING FROM A MEANS-ORIENTED LAW TO A GOAL-ORIENTED SWIMMING-POOL LAW IN THE NETHERLANDS: TECHNOLOGICAL CONSEQUENCES

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In the context of the policy of the Dutch Government to reduce the legal rules and regulations, the Dutch law which currently regulates Health and Safety in public swimming pools is being reviewed. Specifically, one of the aims is to replace the current law, based on rules that specify devices, operating conditions, and quality parameters, by a law that specifies water quality only. Consequently, the operator of a swimming pool may choose any technology or combinations of technologies which results in the specified water quality. As an added benefit, this approach could encourage innovation in swimming-pool technologies. To advise the Government on the minimum set of water-quality parameters that ensures health and safety of swimmers, independent of the technologies employed, a team of experts was set-up. The team composition was choosen such that all necessary technological expertises in the swimming-pool field were represented. It is shown that many currently regulated operating parameters like filtration, suppletion, residence time, etc. can be omitted from the specifications without jeopardizing health and safety. A judicial combination of many of the well-known water-quality parameters, with just a few additional parameters, will suffice. This, however, is not the case for chemicals added to the poolwater, without exception. In this situation, no relevant water-quality parameters can be established *a priori*. In this paper, the various reasons for this are elaborated upon. Consequently the set of water-quality parameters presented here is based on chemicals that are widely employed and for which the various risks are well documented. At the same time, criteria are presented that novel chemicals should comply with. Particular attention will be paid to minimizing risks for the formation of disinfection byproducts, and possible interactions between chemicals added.

10-VI ASSESSMENT OF POOL TANK HYDRAULICS TO INFORM POOL DESIGN AND OPERATION DECISIONS

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Throughout the history of public baths the primary focus of water quality management paradigms has changed as knowledge about the potential health impacts and prevention methods has improved and new technologies have become available. Most recently environmental and economic pressures have resulted in a drive to adopt different technologies and operational procedures. Although many of these changes have been shown to result in improved environmental and economic performance, little attention has been given to the potential effects they could have on other aspects of a pool environment. In particular there appears to be a significant lack of knowledge surrounding the nature of water flows within the pool tank itself and its effects on both chemical distribution and particulate removal. Assessment of these potential hydraulic effects associated with changing various aspects of pool operation and design was undertaken using computational fluid dynamics. This paper provides the results of these assessments of the hydraulics within the pool tank and relates the findings to potential issues with the management of pathogen control.

11-VI AN INVESTIGATION INTO THE ENERGY EFFICIENCY OF PIPEWORK SYSTEMS IN COMMERCIAL SWIMMING POOLS

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It is estimated that 30 million new electrical motors are sold each year for industrial purposes; some 300 million motors are used in industry. These electric motors are responsible for 40% of global electricity used to drive pumps, fans, compressors and other mechanical equipment. Furthermore the US Department of Energy estimates that pumping alone accounts for 20% of the world's energy use by electric motors. Current tendency in industry is to minimise installation costs, possibly at the expense of hydraulic efficiency. The Construction Industry Research and Information Association (CIRIA) identify head loss caused by flow velocity and pipe diameter as having a direct effect on energy loss. Friction losses along the pipe lengths cause a steady fall in both the total energy and the hydraulic gradients. The slope of the gradient is a function of the flow velocity, the pipe friction factor and the pipe diameter. Energy is frequently wasted in pumping systems and this wastage can be significant over the design lifetime of the plant. There is a potential difference of 80% in energy consumption between the worst designed constant flow systems and best designed variable flow systems. Pipe sizes will normally be determined by the designers chosen range of acceptable pressure losses per meter of pipe length. (Typically between 50 and 250 Pa/m for main distribution branches) systems designed with pressure losses significantly above this range will incur additional pump energy consumption. The effects of additional energy consumption will be examined when considering the whole life costs of plant operation and maintenance. The benefits provided to the flocculation, filtration and disinfection systems should also be acknowledged when optimising the efficiency of pipe systems. These benefits may include improvements to flocculation - filtration performance, lower disinfectant demand and better water quality.

12-VI TRAINING OF THE POOL STAFF IN GERMANY

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Proper operation of a swimming pool is one of the most important preconditions for providing safety, managing risks and not at least for a sufficient operation of the water treatment facilities. The heart of pool operation is the pool staff, well-trained for their duty on the job. The quality of the training has a big influence on the efficiency of the water treatment and thus in the end on the water quality. The poster will give an overview of the training of pool staff and water-related operational procedures in Germany. Water related examples will be given on each topic.

German dual education. The training of young people in Germany in the fields of trade and business is different as in most other countries. There is a special "dual system" in Germany, characterized by:

- on-the-job training in a swimming pool;
- theoretical training at a special school for apprentices.

Training in school. The subjects for swimming pool staff in school (780 hours) are pool management, pool technique, theory of sports, biology, theory of rescue operation, chemistry, workshop training (technical subjects), swimming, business administration, social studies, German, religion, computer programmes.

The water-related training contains the following lessons:

- significance of water in the environment and in the pool (60 lessons/hours);
- disinfection of the pool water (40 lessons/hours);
- operation of the filtration plant (40 lessons/hours).

Practical training. The water-related operational procedures contain requirements for:

- personal protective equipment;
- operating the water treatment plants;
- control of function and safety check;
- dealing with longer closing times;
- transport of chlorine gas.

Handling of chlorine outflow, chlorine outbreak:

- emergency procedures;
- behaviour of the staff;
- first aid for chlorine gas related hazards.

13-VI USING TECHNOLOGY TO TRACK, ANALYSE AND REPORT ON WATER QUALITY IN LEISURE FACILITIES

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The leisure industry is a dynamic and fun environment in which to work. Effectively managing leisure staff, qualifications, training and safety obligations as well as monitoring water treatment can be time consuming, laborious and can take qualified staff away from front line duties that actively aid the preservation of life. Often there is a lack of action when poor readings are identified from testing pool water. In this situation, managers need to be alerted quickly so that appropriate action can be taken for the safety of the customers and the maintenance of pool water standards. Ensuring pool water is treated correctly is critical to organisations as it ensures aquatic facilities remain fully compliant with Industry Laws and that customers are in the safest possible environment. In the UK there have been numerous incidents where operators have fallen foul of record keeping requirements. The in-depth investigations frequently highlight failings in systems and processes leaving aquatic environments falling short of standards. This problem becomes exponentially more complex and can result in investigations from Environmental Health and associated bodies. In extreme cases, legal claims can be made related to illness caused by poorly treated pool water. In this session, STA's Director of Operations, Theo Millward, will discuss the wider problems operators are facing and how new technologies can provide cost effective solutions that not only provide early warning systems to senior management but can also work with staff to keep a watchful eye over State and Corporate Governance standards resulting in compliant, robust organisations.

Session VIII

Workshop

Emerging etiologic agents and advanced technological tools

Chairperson

A. Mavridou, S. Giampaoli

LEGIONELLOSIS RISK IN SWIMMING POOL AND SPA

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Spas used for either therapeutic or recreational aims are considered at risk for legionellosis occurrence. Thermal water is normally used at temperature between 30 and 40°C, ideal for *Legionella* growth, with a potential risk for users. Inhalation of colonized aerosol has been associated with sporadic cases or clusters of both Legionnaires' disease and Pontiac fever, particularly involving immune depressed subjects. Italian and European guidelines have been issued to prevent and control this risk. At the spring, thermal water can contain small concentrations of legionellae, but within the distribution lines the amplification of these bacteria is promoted by stagnancy and incrustation, a frequent phenomenon also associated with the high mineral content of these waters. In addition, the detachment of dead cells, body lotions/creams residuals and skin debris in swimming pools favorites the bacteria multiplication. The devices/treatments more involved in transmission risk are inhalation therapies, frequently utilized by persons with chronic disease, showers and whirlpools, largely used also in the wellness centers. We revised the studies on *Legionella* spp presence in hot springs and related structures. The majority of published reports documented the germ contamination both at the source and along the distribution lines up to the point of use with increasing concentrations. Particular water characteristics such as high levels of sulfur and/or carbonate seem to be unfavorable to legionellae colonization but further studies are needed to deep this aspect. Contamination risk is less relevant for swimming pools due to high chlorine content, unless an insufficient disinfection plan is applied. From eighty years, about 50 studies have been published documenting cases of Legionnaires' disease associated with spas. The majority of them occurred in Japan, where also a large outbreak is described with more than 300 persons involved. In almost all cases, *L. pneumophila* was the responsible germ and during the environmental inquire *Legionella* spp was found in many points of the spas: in spring water, in the distribution system, in the tank, in devices for nasal irrigation and aerosol therapy as well as in the whirlpool bath and swimming pool. To study the infection risk, the antibodies against *Legionella* have been evaluated in workers and patients attending the spa; the antibodies presence was found in a decreasing proportion from therapists to administration personnel. In conclusion, we underline the need for an accurate surveillance and control of *Legionella* spp and other waterborne germs in spas and other structures where inhalation of aerosolized water is expected.

AN OUTBREAK OF LEGIONNAIRE'S DISEASE LINKED TO A WATER POOL WITH AEROSOL PRODUCING ATTRACTIONS, AUSTRIA 2010-2011

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We report on a community-outbreak related to a spa hotel in Austria, 2010/2011. The investigation aimed to identify the source for rapid implementation of control measures. A confirmed case was a person, who 1) presented with clinical signs of pneumonia within ten days after visit of the spa and 2) fulfilled one of the following laboratory criteria: detection of *Legionella* by culture, real-time-PCR, urinary antigen test, or by a 4x titre rise of *L. pneumophila* specific antibody. A probable case fulfilled criterion 1) only. Cases were interviewed on usage of diverse water pools within ten days prior to onset. Samples were collected from the hotel water system and pools and tested for *Legionella*. Recovered water and human isolates were characterised by MAb-typing and sequence-based typing (SBT). Thirteen outbreak cases were identified (11 confirmed) between December 28, 2010 and January 30, 2011. The median age was 60 years (range: 37-78 years), three cases were female. No deaths occurred. The link among all cases was using the indoor pool, which featured an aerosol producing pool shower. *L. pneumophila* serogroup 1 (*L. p.* sg 1), MAb-type Allentown/France was recovered from respiratory secretions of one case, the indoor pool samples (210cfu/100mL), and from the pool shower (40cfu/100mL). Samples collected behind the pool multi-layer filters tested positive for *L. p.* sg 1 of MAb-type Allentown/France, MAb-type Philadelphia and of MAb-type Olda at levels of 7000 cfu/100ml and 11.000cfu/100ml, respectively. Water and case *L. p.* sg 1, MAb-type Allentown/France isolates were indistinguishable from each other by SBT, yielding sequence-type 82. The investigation revealed the indoor water pool as most likely outbreak source, and the insufficiently maintained pool-filters as source of *Legionella* growth. *Legionella* testing of samples collected behind the pool-filters was not routinely performed prior to the outbreak. The released new bath hygiene regulation requiring also sampling behind filters should prevent outbreaks of Legionnaire's disease due to malfunctioning pool-filters.

OCCURRENCE OF LEGIONELLA SPP. IN THERMAL ENVIRONMENTS: CHARACTERIZATION OF VIRULENCE FACTORS AND EVALUATION OF BIOFILM FORMATION IN ISOLATES FROM A SPA

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The aim of the present survey was to evaluate the occurrence of *Legionella* spp. in a spa water systems. So, in the course of 10 months, 140 samples of both tap and thermal waters were collected. Sampling procedure was in accordance with the Italian Guidelines for the Prevention and Control of Legionellosis (2000). The 10^3 CFU/L limit for *Legionella* spp. concentration in water is actually enforced as, in correspondence of this value, scientific data proved a real infective risk for exposed people. The water was analyzed according to ISO 11731:1998. Then, Legionella strains were tested for the production of specific virulence factors with particular regard to the production of proteins with cytotoxic and hemolytic action. Finally, the ability of the isolates to form biofilm and, then, to colonize water pipes surfaces was assessed. *Legionella* spp. amount was lower than 100 CFU/L in 91% of samples while the 4% ranged from 100 to 1,000 CFU/L. *Legionella* spp. concentration was between 1,000 and 10,000 CFU/L in the 5% of analyzed water samples. It is important to remark that *Legionella* spp. resulted always absent in thermal water, mainly used to cure respiratory tract diseases. The serological typing for *L. pneumophila* gave a negative response for all strains. Nevertheless, a bio-molecular analysis (rDNA 16S and ITS region sequencing) of the most frequent isolates was carried out, providing the identification of each strain (BLAST, NCBI). Two strains showed some positive responses to the in-vitro virulence tests, with regards to proteinases and gelatinases. None of the six isolates were classified as strong biofilm former but they showed a moderate to weak ability to form biofilm on poliethylene. This result is significant if we consider that large part of the spa pipelines is internally coated with a plastic material. The highest frequency of isolation of *Legionella* spp. was detected in the unit for Thermal Mud Therapy. The relative risk assessment for above mentioned unit, calculated among the different units of the spa, showed the higher value, 1.69, proving a major risk for Thermal Mud Unit customers to be in contact with water contaminated by *Legionella* spp. The analysis of collected data shows that *Legionella* spp. contaminate moderately the examined spa. The absence of *L. pneumophila* could be related to the chemical - physical nature of water, characterized by a high hardness (73°F). Although, no strain of *L. pneumophila* was isolated, the presence of different environmental strains of *Legionella* spp. should not be underestimated because even if they didn't show a significant in-vitro virulence, they could represent a real risk for immunodeficient customers like old and sick people. Therefore, control measures must be applied not only in response to cases of Legionnaires' disease, but especially to prevent them.

RISK OF LEGIONELLOSIS ASSOCIATED WITH SPA-POOLS IN HUNGARY

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Spa-pools, especially whirlpools or pools with water features are known hazard for Legionella exposure, due to their temperature and aerosol formation potential. In Hungary, thermal spas and associated health services are a major tourist attraction, thus the investigation and mitigation bathing related health risks is an economic as well as a public health imperative. In the current Hungarian regulation, Legionella is not part of the mandatory pool water quality monitoring scheme. Spa-pools, thermal pools and whirlpools were sampled and analyzed for Legionella and other microbial and chemical parameters. Pools for surveillance purposes were selected randomly, however, in three instances, spa-pools were sampled as part of the epidemiological investigation of travel associated clusters of legionellosis. Approximately 20% of thermal pools and spa-pools were colonized by *Legionella* sp. according to the survey. Non-disinfected pools had a higher incidence rate. Legionella counts were often above the WHO guide levels. However, as thermal pools are intended for sitting without the submersion of the head, and usually are not equipped by aerosol generating devices, the actual risk of exposure is low. Three travel associated clusters of legionellosis were identified in 2010-2012 in hotels providing pool services. In all three, whirlpools were the most likely source of infection, though levels of colonization varied widely. Pool water disinfection and its monitoring was insufficient in all three units. Results of both the surveys and the epidemiological investigations confirmed the necessity of a risk-based regulation of Legionella in pools and spas.

SWIMMING POOLS WATER CIRCULATION OPTIMIZATION WITH CFD ANALYSIS. FROM COMPETITION LAP POOLS TO FREEFORM RECREATIONAL POOLS

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State-of-the-art filtration and disinfection solutions guarantee a safe and efficient swimming pool only when supported by a well-designed water circulation system. In order to optimize the swimming pool circulation design and to get a homogenous distribution of the treated water, the traditional approach can now be supported by the application of Computational Fluid Dynamics (CFD) analysis. The aim of this abstract is not to discuss the general advantages of CFD modeling, but to focus on specific applications of this tool in the swimming pools field. First of all, the use of fluid-dynamic simulation for such purpose is not straightforward and a long path was necessary to obtain the first reliable results. In particular the computational domain is characterized by a large water volume compared to the small inlet/outlet dimensions which leads to a complex meshing definition; in parallel the existence of both turbulent and laminar conditions requires a careful evaluation of the whole model and a step-by-step mesh refinement to reach the convergence of the solution. All the results described hereafter have been validated by a complete set of tests realized both in laboratory and in real conditions.

1. For competition pools, rectangular shaped, we were already able to design an efficient and homogeneous circulation system through wall inlets, but in some cases this could result in a discomfort of the athletes pushed by the water jets. The challenge we succeeded in, was obtained through a new CFD optimized wall inlet, able to maintain the hydrodynamic efficiency and avoiding all "pushing" effect.
2. For recreational pools, typically with a specific freeform shape, the opportunity offered by CFD allows to predict all the physical parameters of interest and even to realize a simulation of the dye-test before the pool construction (the dye test is a water circulation validation method according to the EN-15288-2:2009). This type of analysis provides for instance the steady-state water velocity field, so eventual stagnant areas are highlighted and solved, the average speed of the rivers can be foreseen and the whole water circulation can be checked and improved, which is difficult with an experience based approach.
3. In general: computer simulation allows the improvement of the hydraulic performance of the pool accessories and provides a fast response to customized requests, like the conversion of a wall inlet with an axial mass flow to a floor inlet with a prevalent radial mass flow, modifying the cover grid and adding a specific insert: for similar projects only one prototype is required and no trial-and-error process need to be undertaken.
4. Finally wherever the users safety and the swimming pool environmental impact are real priorities, the CFD provides undeniable advantages in the design phase.

Session VIII

Workshop

Health promotion and emergency management in pools

Chairperson

A. Scapigliati, M. Bonifazi, M. Santomauro

CARDIOVASCULAR AND RESPIRATORY HEALTH BENEFITS OF AQUATIC ACTIVITY

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Cardiovascular Diseases (CVD) are the leading cause of death and disability globally, resulting in about 30% of all deaths across the world and more than half of all deaths in Europe. Respiratory disease follows behind CVD but has grown to 4th place globally and is a tremendously costly cause of disability and death across the age span with a striking increased incidence in children. In both of these health issues, there are tremendous potential gains to be achieved through expanding public awareness, access and participation in aquatic activity. The aquatic environment profoundly impacts the physiology of cardiovascular and respiratory function in ways that have dramatic potential health-related benefits. There is a significant body of scientific research demonstrating that even simple immersion in water produces important cardiac effects and these effects are even greater with activity in water. Many recent studies have shown that chronic heart disease responds very positively to aquatic activity, a fact that has escaped both public and professional awareness. Aquatic activity decreases the circulatory workload of the heart, facilitating blood circulation, muscle perfusion and cardiorespiratory fitness while generally decreasing blood pressure. Immersion also greatly changes the mechanics of the respiratory system and can be used effectively to reduce the impact of chronic lung disease, emphysema and asthma. Aquatic exercise has been shown to improve respiratory function, physical fitness and quality of life in asthmatic individuals, and has also been shown to improve lung function, daily activity participation and quality of life in chronic obstructive lung disease through development of respiratory endurance and strength. These benefits are achieved in both young and older individuals yet remain tremendously underutilized. In view of these important realities, our industry must take a far more proactive role in growing public and professional awareness and access to these health benefits. It is not only important for our industry to do so, and even more important from a public health standpoint as the catastrophic costs of providing health care threatens the economic stability of all developed nations.

THE EMERGENCY MANAGEMENT OF DROWNING IN SWIMMING POOLS

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This presentation overviews incidence, pathophysiology and initial treatment of visitors of Swimming Pools (SP) who drown. A check-list is proposed to be better prepared.

Incidence. No international data is available on Swimming Pool Drownings (SPD) due to lack of registration or reluctance to provide data. Most SPD are due to the inability to swim, a mismatch between swimming competencies and the environment, or the interference of a large variety of medical problems.

Pathophysiology. An immediate circulatory arrest due to a sudden cardiac problem is unlike the gradual cardiac arrest of a healthy heart after drowning. The function of the heart of a drowning victim will stop when the oxygen content in the circulating blood becomes fatal low. In general this happens after 5-10 minutes under water. This period may extend to one hour, but the required circumstances, notably ice cold water, are uncommon in SPs. Immediate detection and rescue are important. In contrast to general beliefs, most drowning victims do not wave their hands or shout for help.

Treatment. Optimum treatment after drowning differs from standard Cardiopulmonary Resuscitation (CPR). Oxygen content in the lungs and blood needs to be corrected as soon as possible with mouth-to-mouth ventilation, if possible started in the water. Cardiac compression-only CPR results in the re-circulation of non-oxygenated blood. Cardiac compression in a non-responding or gasping drowning victim is often not needed. In apparently dead drowning victims, the remaining minimal circulation improves due to oxygenation-only. For the same reasons, an AED is rarely needed and connected after ventilation and compressions are established and the Emergency Medical Services system alerted. Ventilation can be very difficult due to water, or vomitus, in the lungs. Expulsion of water by abdomen or lung trusts increases this risk and should be avoided. Additional oxygen during mouth-to-mouth ventilation and in spontaneously breathing victims improves oxygenation. Because of late respiratory complications, drowning victims should attend the Emergency Room.

Checklist. In SW, drowning is a high-impact and low-frequency event. To act skilfully and routinely, a checklist may be helpful to be well prepared. This checklist includes regular team (re)training of rescue and CPR in various drowning scenarios, public visible drowning CPR protocols, regular checks of stretchers, oxygen and AED, standardised communication procedures for the emergency dispatch centre and the swimming pool reception, clear access and internal and external evacuation routes for the EMS, procedures for registration, evaluation and the emotional repercussions. Most important however is that measures are taken that prevent a drowning to happen.

Session IX

Harmonized guidelines and regulations

Chairperson

R. Aertgeerts, V. Romano Spica

THE GUIDANCE ON SAFETY IN SWIMMING POOLS IN ITALY

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The Italian guidance on *Hygienic aspects for the construction, maintaining and control of swimming pools* were presented by the Italian Ministry of Health, with the technical support of the Istituto Superiore di Sanità (the National Institute of Health in Italy, ISS), the National Olympic Committee and representatives of the Italian Regions in 2003. This guidance is the first national legislative provision intended to protect the health of bathers and pool workers by providing an all-embracing control of the water and environment. General principles and minimum safety standards of hygiene throughout the country are defined through physical, chemical and microbiological parameters. It came into force after a legal approval, through Regional regulations, from each of the 20 Italian Regions and established the essential hygienic, technical and managerial requirement of swimming pools. As a further development of the Agreement, a set of rules between the Regions and autonomous Provinces of Trento and Bolzano has been then implemented and formalized within the *Inter-regional protocol of swimming pools*. The guidance is intended to be used for controlling the hazards that may be encountered in recreational water environments. It is applicable to pools supplied with fresh water, whether they are indoors or outdoors; public, semi-public or domestic; supervised or unsupervised. Pool water must comply with the parametric values established for a set of physical-chemical and microbiological parameters. Substances to be used for disinfection, flocculation, pH-correction and algaecides are specified and their purity degree indicated. Hygienic-environmental requirements, such as thermo-hygrometric, acoustic and lighting-technical conditions are also fixed. The more innovative element of the guidance consists in the designing and implementation of an internal control (autocontrol) plan under the direct responsibility of the administrator of the facility. The task of issuing detailed rules of implementation of the agreement is demanded to the Regions. The local health authority is responsible for analytical controls of the fixed parameters, supervision of the autocontrol documents - produced by the self checking activities - and surveillance on the suitability of the corrective actions adopted in case of exceeding values or critical circumstances. A revision of the guidance is now underway. Currently, a working group instituted at the Ministry of Health is working on the revision of the Italian Agreement, to take into account the progress in scientific and technical knowledge. The inclusions of new microbiological and chemical parameters and the removal of other ones less relevant for bathers’ safety are considered within the revision. Alternative or new treatment technologies are also considered to combine with those already authorized for microbiological control and for the minimization of disinfection by-products.

PROTECTING A NATION OF SWIMMERS: USING SURVEILLANCE, DISEASE, AND OUTBREAK DATA TO CHANGE PUBLIC HEALTH POLICY AND INFLUENCE REGULATION

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Introduction. In the United States, no federal agency regulates the design, construction, operation, and maintenance of Treated Recreational Water Venues (TRWVs), such as pools. Regulations for TRWVs are written and enforced at the state or local level. This approach has led to great variability in regulations to protect swimmer health and inefficiencies and gaps in effective public health policy across the U.S..

Methods. We used national surveillance data on waterborne disease, outbreaks, and other health events (*e.g.* chemical injuries) to help guide the development of a national Model Aquatic Health Code (MAHC) as a resource for jurisdictions reviewing and updating their regulations to improve swimmer health at safety at TRWVs. Since 1978, national surveillance data on outbreaks associated with TRWVs have been collected.

Results. TRWV use was associated with 696 outbreaks from 1978 to 2008, with 419 (60.2%) occurring in the last decade from 1999-2008. Syndromes documented included Acute Gastrointestinal (AGI), Acute Respiratory (ARI), skin, ear, eye, neurologic, and mixed illnesses. AGI was the most commonly reported outbreak-associated illness and accounts for 218/419 (52%) of reported outbreaks during the last decade. The chlorine-tolerant parasite *Cryptosporidium* was the major cause (83%) of AGI outbreaks over the past decade [outbreak data for 2009-2010 will be finalized in 2012]. Lessons learned from various data sources are incorporated into the MAHC including improved 1) water treatment to inactivate *Cryptosporidium* and control biofilms, 2) indoor air quality, 3) operator training, 4) preventive maintenance, operation, and water quality monitoring, and 5) swimmer awareness/hygiene. Swimmer protection will also be improved by enhancing pool program operation, inspections, and data collection to inform future decision making. These lessons have served as the foundation for creation of the MAHC; the first edition to be completed by the end of 2013.

Discussion. To improve health and safety, the MAHC must address *Cryptosporidium* removal/inactivation, disinfection by-products, chemical and other injuries and drowning, and improve overall design, maintenance, and operation. Creating a national model for state and local use should reduce the time and resources currently expended in creating and updating pool codes and lead to more data-based design and operational parameters. This will be critical to the continued success and expansion of swimming as an activity associated with many positive health and psychological benefits.

NEW REGULATIONS FOR SWIMMING POOLS AND SPAS IN THE NETHERLANDS

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The current regulation concerning swimming pools in the Netherlands dates from 1969. A few amendments were made in the 1980's and in the year 2000. The regulation has a legal status and pool operators and managers are required to comply with the standards outlined in the regulation. The regulation comprises of standards for chemical, physical and microbiological water quality, but also specifies requirements for pool operation such as the capacity of the pumps, the procedure for and the frequency of filter backwash and the volume of water that should be replenished for each bather per day (i.e. 30 L of drinking water). The aim of the regulation is the achievement of a safe and healthy swimming environment through strict requirements. Recently, because of new insights, it was concluded that many of the parametric values previously set were outdated and needed replacement. Moreover, the Dutch government has decided that for pool water regulation, it wants to move away from strict requirements towards a regulation that specifies that the swimming pool environment should be safe and healthy for its users, regardless of the way pool operators achieve this goal. Such an approach gives pool managers and operators the opportunity, but also the responsibility, to make their own choices in how to achieve this goal. Additionally, the approach accommodates innovation in pool operation and the application of novel technologies. However, an abrupt transition from the old to the new approach could cause some serious problems. Therefore, the new regulation will give pool managers the option to choose for the use of one or more of the standards from the old approach, such as supplying 30 L of water for each bather per day. A working group of experts has defined a set of "state of the art" parametric values for pool water and - for indoor pools - the air above the water. Pool managers are obliged to make a so-called health and safety plan in which they identify the risks regarding health and safety of pool users and indicate how they intend to manage these risks. The health and safety plan should include a monitoring program for pool water (and in some cases: the air). Since pool managers have a certain degree of freedom of choice in how they achieve a safe and healthy pool environment, it is expected that the new approach may lead to a reduced use of water, energy and chemicals in the (near) future.

A NEW LEGAL REGULATION FOR THE QUALITY OF BATHING WATER IN AUSTRIA

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In Austria a long tradition exists in legislation on the quality of bathing water to protect the health of the bathers. In 1976 the national council adopted a law followed by a regulation in 1978. The main objective of this comprehensive provision is the prevention of diseases transmissible via the water route. In 2006 the European Parliament has established a directive concerning the management of bathing water quality, which repealed the directive 76/160/EEC. However, this common European regulation solely deals with surface bathing waters and explicitly excludes the quality of water in swimming pools and spa pools. By October 1, 2012 a new Austrian regulation was enacted which substantially expanded the hitherto existing scope. The regulation now comprises requirements on technical facilities, operation, water quality and control of swimming and whirl pools, whirl tubs and small natural swimming ponds as well as on auxiliary installations. The main improvements include: 1) Whirl tubs have been now incorporated in the regulation since a severe health risk has been recognized due to formation of biofilms in the installed piping system. High concentrations of biofilm microorganisms like *Pseudomonas aeruginosa*, *Legionella pneumophila* and amoebae multiplying in the piping system may appear in the bathing water. 2) The strategy for the control of water treatment systems for pools has been adapted to a microbiological stage-by-stage check. Special emphasis is laid on the control of the core piece of the water treatment system, which is the filter of the flocculation-filtration unit. Filters are a favourite space for the proliferation of microorganisms. Investigation of samples taken directly after the filter represents a valuable tool to check their microbial load. 3) Disinfection By-Products (DBP), which are generated during the chlorination process of the pool water, may pose a health risk to the bathers via inhalation, skin absorption and ingestion. The new regulation has now included the parameter Trihalomethans (THM) on the one hand as harmful substances themselves and on the other hand as indicator for total DBP levels. The concentration of THM in pool water should be less than 20 µg/L and must not exceed 100 µg/L. Since the analysis of THM in the complex matrix of pool water differs from that in *e.g.* drinking water, an obligatory method has been laid down in the regulation. The enhanced quality management of bathing water as given in the revised regulation will contribute to increase the positive health effects of swimming due to reducing potential adverse health risks for the bathers.

A UK CODE OF PRACTICE FOR PUBLIC SWIMMING POOLS

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History. The Pool Water Treatment Advisory Group (PWTAG) was from 1929 to 1984 a government sub committee providing guidance on the Treatment of Water of Swimming Pools. Today PWTAG still plays a formative role in setting standards and providing guidance to the UK pool industry but does so as a voluntary body of experts. Some 10 years ago PWTAG produced its first Code of Practice. In 2012 facing increasing public health challenges for swimming pool operation the decision was taken to introduce a new Code.

Implications. The Code of Practice combines all the knowledge necessary to operate a public pool in one short yet comprehensive document. It directly reflects PWTAG's publication "Swimming Pool Water" together with what is increasingly becoming our main communication channel - the PWTAG website carrying all the UK topical issues on swimming pool water together with a World Wide Reference base.

Need. The problems with UK pools today are mainly health concerns. People who use pools expect and demand a healthy experience. To provide this pools must be designed and operated in accordance to well established practices which will not only provide a healthy experience but will also mitigate against disease and infection. Following the Code will help ameliorate these. There are many hundreds of cases of Cryptosporidium each year, many of which have been linked to swimming pools. Currently three to four major public pools are closed each year due to such public health risks. The UK National Health Service has for the first time issued guidance for investigations into these outbreaks. There is also concern also that poorly run pools may contribute to childhood asthma which whilst not scientifically justified at this point in time, the medical community conclude that management of swimming pools should keep levels of disinfection by-products as low as is consistent with adequate anti-microbial activity. This requires good management practice and knowledge both of which are key features of the PWTAG Code.

The Code of Practice. This paper will include an explanation of the main requirements of the Code for swimming pool operators in the UK. The standards and practices required for safe, healthy swimming pools.

THE NEW GERMAN STANDARD DIN 19643 "TREATMENT OF SWIMMING POOL WATER"- SOME INSIGHTS

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In Germany the Protection Against Infection Act (IfSG Infektionsschutzgesetz) is regulating the water quality in public and commercially used pools: the water quality in pools that are not used exclusively on a private basis has to be of such a quality that there are no harmful effects to human health, especially by pathogens. Microbiological, physicochemical and chemical pool water quality parameters are not regulated by law. They are defined in the German standard DIN 19643 "Treatment of Swimming Pool Water". This standard is the key to a safe pool water quality according to the IfSG and therefore the second most important regulation in Germany for swimming pool water. The aim of the standard is to consistently ensure a good pool water quality with regards to hygiene, safety and aesthetics. Also, the wellbeing of the bathers must be taken into account, e. g. through minimization of disinfection by-products, as well as economical aspects with regards to economically-viable construction and operation of pools. Recently, the standard has been completely revised. The updated version of the DIN 19643 consists of 4 parts, and was published in November 2012. To enable adaptation of the standard to future developments, part 1 of the standard comprises general requirements to be made on the pool water quality and general demands on the construction and operation of swimming pools. The subsequent parts of the new DIN 19643 concern the requirements that need to be considered for individual combinations of water treatment processes which applied to achieve and maintain the necessary pool water quality. Part 2 is dealing with combinations of processes with fixed bed filters and precoat filters. In part 3, combinations of processes with ozonation are described in detail. Part 4 is completely new and covers combinations of processes with ultrafiltration. The revised standard has a simpler and clearer form than the previous version. It is up-to-date and includes the latest state-of-the-art-technology. Some insights into the new German standard and some examples of innovations (for example limit values for the sum of chlorate/chlorite and for bromate in pool water, implementation of ultrafiltration etc.) are given.

AN OVERVIEW OF POOL AND SPA REGULATIONS IN MEDITERRANEAN COUNTRIES

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The Mediterranean area is both densely populated and a very popular tourist destination. This study aimed at gathering up-to-date information on current national pool and spa regulations, using a purpose-designed questionnaire. The questionnaire was sent to the national authorities and experts in the field. It contained 39 questions, 22 for pools and 17 for spas, and included questions on construction, operation, water quality, staff, users and public information. We received the questionnaire partly or fully answered from 20/22 countries. In 18 countries there is an obligation to obtain official authorization in order to operate a pool; 17 countries have a national regulation, while 2 countries apply WHO Guidelines; 16 countries have provisions specifying the design and construction of pools, and the obligation to keep records; in 14 countries there are provisions on the prevention of accidents and require the presence of a lifeguard; 16 countries require the microbiological and chemical quality of the water, 15 specific requirements regarding disinfection procedures and the level of disinfectant and 14 specific circulation and hydraulics to the pools. In 13 countries there are specific requirements on filtration; Moreover, 16 countries have specific requirements for the facilities and16 provide specific guidance to cleaning; in 15 countries it is obligatory for bathers to pre-shower before using the pool. Also there are provisions setting out specific requirements regarding the bathing load; in 13 countries specific requirements apply to aeration and lighting for indoor pools, and special training for the pool staff is obligatory. In 10 countries there are specific requirements for pools dedicated to specific groups of people. Provisions detailing occupational health issues are included in the regulations of 6 countries; only 3 countries have provisions addressing ethical and/or social issues included in the regulation. As for spas, only 11 countries have specific regulations. All 11 regulations include provisions on water quality, but less than half cover other issues. An attempt was made to evaluate the regulations by geographical region: the North African countries appear to place an emphasis on hydraulics and circulation issues, the Near Eastern countries safety matters and hygiene of facilities, the EU countries occupational health, and non-EU European countries water and air quality, though these emphases, in each case, do not preclude the overall range of issues covered by such regulations.

Conclusion. The WHO decision to add regulations on occupational health, social and ethical issues, and indoor air quality would seem to be justified, at least for Mediterranean countries.

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