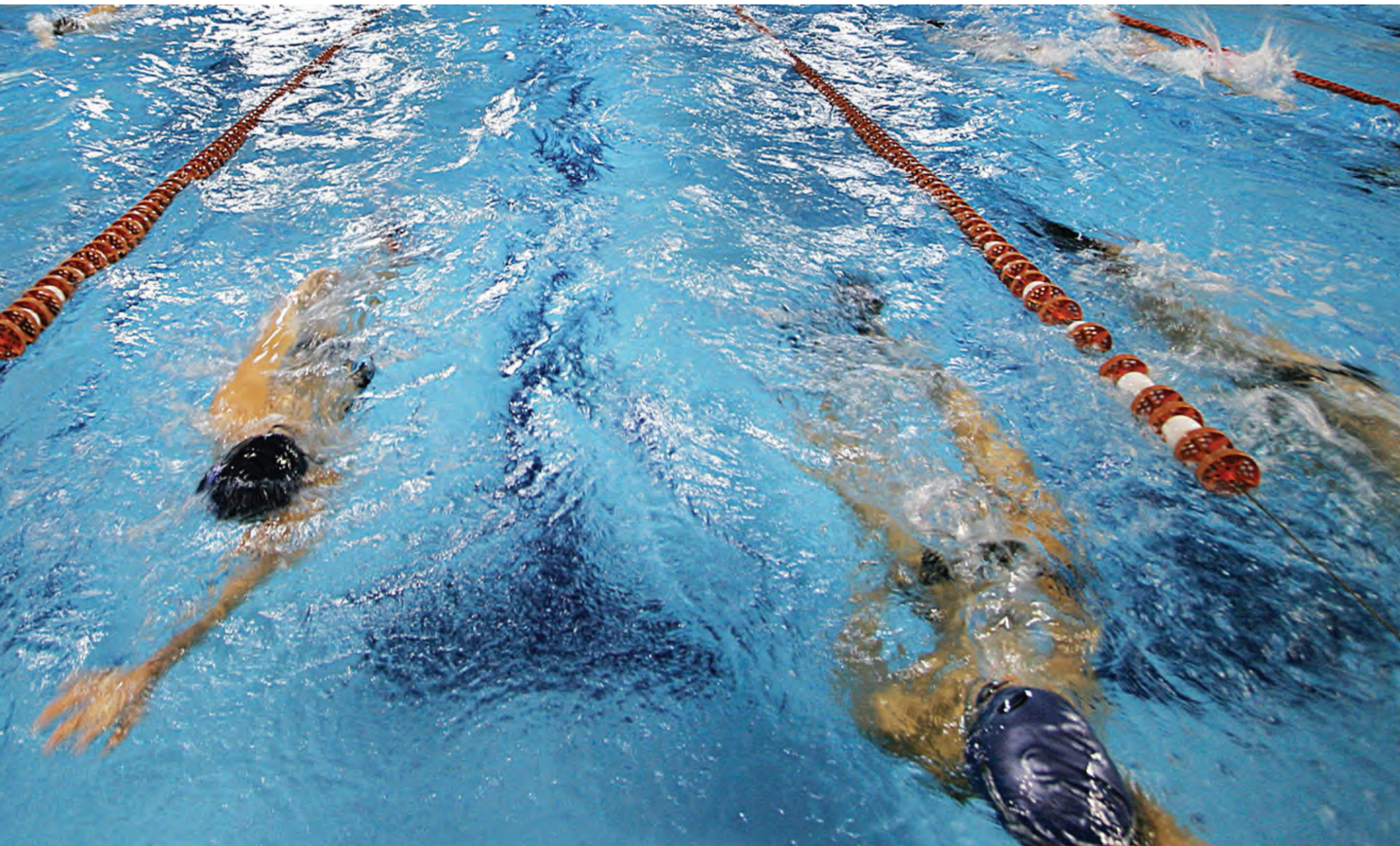
Swimming Pool & Spa
7th International Conference

2 –5 May 2017
Kos Island, Greece

PROGRAM & INFO



TUESDAY — MAY 2

17:00-19:00 — **REGISTRATION**

19:00-21:00 — **WELCOME RECEPTION**

WEDNESDAY — MAY 3

08:30-09:30 — **REGISTRATION**

09:30-10:00 — **OPENING CEREMONY:**
WELCOME FROM ORGANISING COMMITTEE

Chair: A. Mavridou, A. Vantarakis

10:00-10:30 PS1

ASKLEPIEIA: EARLY EQUIVALENT OF SANATORIA AND HEALING BATHS

Stefanos Geroulanos

President of International Hippocratic Foundation
Chair of Medicine, World Academy of Letters, Cambridge &
Membre extraordinaire de l' Academie Internationale d'Histoire des Sciences, Bruxelles

10:30-14.00

SESSION 1
MICROBIAL AND CHEMICAL QUALITY IN POOL AND SPAS

Chair: J.L. Boudenne, M. Keuten

10:30-11:00 KS1

SWIMMING IN A POOL: HOW HIGH IS THE RISK OF AN INFECTIOUS DISEASE?

Ilias Tirodimos

Aristotle University of Thessaloniki, Greece

11:00-11:15 O1

COLONIZATION OF LEGIONELLA SPECIES IN RECREATIONAL WATER SYSTEMS IN CRETE: A 28 YEAR SURVEILLANCE STUDY

Papadakis A [1, 2], Chochlakis D [1, 3], Keramarou M [1], Sandalakis V [1], Tselentis Y [1], Gikas P [4], Psaroulaki A [1, 3]

[1] Laboratory of Clinical Bacteriology, Parasitology, Zoonoses and Geographical Medicine, School of Medicine, University of Crete, Heraklion, Crete, Greece
[2] Public Health Authority of Heraklion, Crete, Greece
[3] Regional Laboratory of Public Health, School of Medicine, Heraklion, Crete, Greece
[4] Design of Enviornmental Processes Laboratory, School of Environmental Engineering, Technical University of Crete, Chania, Greece

11:15-11:45 — **Coffee break**

11:45-12:15 KS2

PARASITES AND THE CREATION OF BIOFILM IN POOL ESTABLISHMENTS

Panagiotis Karanis

Center for Biomedicine and Infectious Diseases CBID, Xining City, P. R. China
Medical School, University of Cologne, Germany

12:15-12:30 O2

FREE-LIVING AMOEBAE AND VIRUSES IN PUBLIC SWIMMING POOLS AND RECREATIONAL WHIRLPOOLS

Rossella Briancesco, Simonetta Della Libera, Marcello Iaconelli, Giuseppina La Rosa, Lucia Bonadonna

Italian Institute of Health, Department of Environment and Health, Rome, Italy

12:30-12:45	O3	***CLINICALLY-RELEVANT FUNGI ON SURFACES AND IN WATER IN AN INDOOR SWIMMING POOL FACILITY*** Yuli Ekowati [1], Anne D. van Diepeningen [2], Giuliana Ferrero [1], Maria D. Kennedy [1,4], Ana-Maria de Roda Husman [3,5], Franciska M. Schets [3] [1] UNESCO-IHE Institute for Water Education, Delft, the Netherlands [2] CBS-KNAW Fungal Biodiversity Centre, Utrecht, the Netherlands [3] National Institute for Public Health and the Environment, Centre for Zoonoses and Environmental Microbiology, Bilthoven, the Netherlands [4] Delft University of Technology, the Netherlands [5] Utrecht University, Faculty of Veterinary Medicine, Institute for Risk Assessment Sciences, the Netherlands
12:45-13:00	O4	***5-YEAR MICROBIOLOGICAL SURVEILLANCE OF SWIMMING POOL WATER IN SW GREECE*** Panagopoulou P [1], Tselepi M [1], Vantarakis G [2], Vantarakis A [1] [1] Department of Public Health, Medical School, University of Patras [2] Region of Western Greece, Patras
13:00-13:15	O5	***ABUNDANCE OF ANTIBIOTIC RESISTANT BACTERIA IN THERAPY POOLS AND SURROUNDING SURFACES*** Koeck DE, Hanifi N, Huber S, Höller C Bavarian Health and Food Safety Authority, Oberschleissheim, Germany
13:15-13:30	O6	***ADSORBABLE ORGANIC HALIDES (AOX) FORMATION POTENTIAL IN SWIMMING POOLS*** B. İlker Harman [1], Qahtan Adnan Ali [2,3], S. Sule Kaplan Bekaroğlu [2], Amer A.S. Kanan [4] [1] Technical Science Vocational School, Suleyman Demirel University, Isparta, Turkey [2] Department of Environmental Engineering, Suleyman Demirel University, Isparta, Turkey [3] Department of Environmental Engineering, The North Technical University, Kirkuk, Iraq [4] Department of Earth and Environmental Sciences, Al-Quds University, Jerusalem, Palestine
13:30-13:45	O7	***500 DAYS OF SWIMMERS: VARIABILITY OF THE CHEMICAL WATER QUALITY OF SWIMMING POOL WATERS FROM THE BEGINNING*** Rhys A A Carter [1], Cynthia A Joll [1], Sebastien Allard [1], Anna Heitz [2], Jean-Philippe Croue [1], Nigel West [3] [1] Curtin Water Quality Research Centre (CWQRC), Curtin University, Perth, WA, Australia [2] Department of Civil Engineering, Curtin University, Perth, WA, Australia [3] Chem Centre, Perth, WA, Australia
13:45-14:00	O8	***OCCURRENCE OF PHARMACEUTICALS AND UV FILTERS IN SWIMMING POOLS AND SPAS*** Yuli Ekowati [1], Gianluigi Buttiglieri [2], Giuliana Ferrero [1], Jennifer Valle-Sistac [3], M. Silvia Diaz-Cruz [3], Mira Petrovic [2,4], Martha Villagrasa [2], Maria D. Kennedy [1,5], Ignasi Rodriguez-Roda [2,6] [1] UNESCO-IHE, Institute for Water Education, Delft, Netherlands [2] Catalan Institute for Water Research (ICRA), Scientific and Technological Park of the University of Girona, Spain [3] Water and Soil Quality Group, Department of Environmental Chemistry, Institute of Environmental Assessment and Water Research (IDAEA), Spanish Council for Scientific Research (CSIC), Barcelona, Spain [4] Catalan Institution for Research and Advanced Studies (ICREA), Barcelona, Spain [5] Delft University of Technology, Delft, Netherlands [6] Laboratory of Chemical and Environmental Engineering (LEQUIA), Institute of the Environment, University of Girona, Catalonia, Spain
14:00-15:00		**Lunch**
15:00-16:30		**SESSION 2 - PART 1 RISK ASSESMENT IN POOL AND SPAS** **Chair:** Lucia Bonadonna, Michael Beach
15:00-15:30	**KS3**	***RISK ASSESSMENT IN POOL AND SPA FACILITIES*** Zarema Obradovic Institute for Public Health of Canton Sarajevo, Bosnia and Herzegovina Faculty for Health Studies, University of Sarajevo, Bosnia and Herzegovina

15:30-15:45 O09

HYGIENIC SITUATION IN NATURAL SWIMMING POOLS (NSP)

Stefan Bruns

POLYPLAN GmbH, Bremen, Germany

15:45-16:00 O10

EVALUATION OF THE IMPLEMENTATION OF THE PUBLIC HEALTH SURVEILLANCE PROGRAM OF SWIMMING POOLS OF THE NORTHERN REGION OF PORTUGAL (2015 and 2016)

Mónica Mata, José Rocha Nogueira

Public Health Department - Regional Health Administration, Portugal

16:00-16:15 O11

THE CHEMICAL AND MICROBIOLOGICAL ASPECT OF SWIMMING POOLS IN KOS

Ioni Trakossa

IONLAB, Kos, Greece

16:15-16:30 O12

ASSESSMENT OF INDOOR HOTEL SWIMMING POOLS IN A SKI RESORT AREA IN GREECE

Mplougoura A [1], Charalampous E [2], Panagopoulou P [2], Zygogianni G [3], Vantarakis A [2], Mavridou A [4]

[1] Department of Public Health & Environmental Hygiene, Region of Central Greece, Viotia Regional Division
[2] Environmental Microbiology Unit, Department of Public Health, Medical School University of Patras, Greece
[3] Development Department Region of Central Greece, Viotia Regional Division
[4] Department of Medical Laboratories, Technological Educational Institute of Athens, Greece

16:30-17:00 **Coffee break**

17:00-18:00

SESSION 2 - PART 2
RISK ASSESMENT IN POOL AND SPAS

Chair: Emanuele Ferretti, Janice Calvert

17:00-17:15 O13

IMMEDIATE CLOSURES AND VIOLATIONS IDENTIFIED DURING ROUTINE INSPECTIONS OF PUBLIC AQUATIC FACILITIES – NETWORK FOR AQUATIC FACILITY INSPECTION SURVEILLANCE, UNITED STATES, 2013

Michele C. Hlavsa, Vincent R. Hill, Michael J. Beach

Centers for Disease Control and Prevention, Atlanta, USA

17:15-17:30 O14

DYNAMIC MODELLING OF SWIMMING POOL WATER QUALITY

Morten Møller Klausen, Gert Holm Kristensen, Peter Vittrup Christensen

Ole Grønborg, UltraAqua A/S, Denmark

17:30-17:45 O15

ASSESSMENT OF MICROBIOLOGICAL QUALITY OF WATER FROM SWIMMING POOLS IN GREECE: 7 YEARS DATA FROM THE CENTRAL PUBLIC HEALTH LABORATORY

Antonia Theofilou [1], Ioanna Spiliopoulou [1], Konstantina Aivalioti [1], Alkiviadis Vatopoulos [1, 2]

[1] Central Public Health Laboratory, Hellenic Center for Disease Control and Prevention, Athens, Greece
[2] Department of Microbiology, National School of Public Health, Athens, Greece

17:45-18:00 O16

ADOPTION OF PUBLIC HEALTH MEASURES IN SWIMMING POOLS AND COMPARISON WITH MICROBIOLOGICAL PARAMETERS

Apostolopoulos S, Panagopoulou P, Vantarakis A

Department of Public Health, Medical School, Patras, Greece

18:00-20:00 **VISIT TO THE ASCLEPEION, THE SANCTUARY OF ASCLEPIUS**

18:00-20:00 **Mini Training Course:**

Construction and management issues for a hotel based good pool/spa

THURSDAY

MAY 4

09:00-11:15

SESSION 3
DISINFECTION

Chair: Paola Borella, Wolfgang Uhl

09:00-09:30 **KS4**

STABILISED CHLORINE - A TICKING TIME BOMB FOR HEALTH IN UNCONTROLLED MARKETS?

Josef Konrad

POOLASIA, Germany

09:30-09:45 O17

AFM FILTRATION AND WATER QUALITY OF AN INDOOR PUBLIC POOL IN THE NETHERLANDS AND AN OUTDOOR POOL IN SPAIN

Howard Dryden

DRYDEN AQUA, Scotland

09:45-10:00 O18

AN INNOVATIVE APPLICATION OF OZONE-UV TREATMENT FOR SWIMMING POOL WATER DISINFECTION

Yuli Ekowati [1], Giuliana Ferrero [1], Yness M. Slokar [1], Joop C. Kruithof [2], Maria D. Kennedy [1, 3]

[1] UNESCO-IHE Institute for Water Education, Delft, the Netherlands
[2] Wetsus, European Centre of Excellence for Sustainable Water Technology, Leeuwarden, the Netherlands
[3] Delft University of Technology, the Netherlands

10:00-10:15 O19

MICROBIAL QUALITY OF SWIMMING POOL WATER WITH TREATMENT WITHOUT DISINFECTION, WITH ULTRAFILTRATION, WITH UV-BASED TREATMENT AND WITH CHLORINATION

Maarten Keuten [1, 2], Marjolein Peters [1], Hans van Dijk [1], Mark van Loosdrecht [3], Luuk Rietveld [1]

[1] Delft University of Technology, Section Sanitary Engineering, Delft, The Netherlands
[2] Hellebrekers Technieken, Nunspeet, The Netherlands
[3] Delft University of Technology, Department of Biotechnology, Delft, The Netherlands

10:15-10:30 O20

INVESTIGATING CHLORINE DIOXIDE AS AN ALTERNATIVE FOR INACTIVATING CRYPTOSPORIDIUM IN AQUATIC VENUES THAT USE STABILIZED CHLORINE

Murphy JL, Arrowood MJ, Hlavsa MC, Beach MJ, Hill VR

Centers for Disease Control and Prevention, National Center for Emerging and Zoonotic Infectious Diseases, Division of Foodborne, Waterborne and Environmental Diseases, Atlanta, USA

10:30-10:45 O21

QMRA FOR AN INDOOR SWIMMING POOL WITH CHLORINATION COMPARED TO A UV-BASED TREATMENT

Marjolein Peters [1], Maarten Keuten [1, 2], Merle de Kreuk [1], Hans Vrouwenvelder [3], Luuk Rietveld [1], Gert Jan Medema [1]

[1] Delft University of Technology, Section Sanitary Engineering, Delft, The Netherlands
[2] Hellebrekers Technieken, Nunspeet, The Netherlands
[3] Delft University of Technology, Department of Biotechnology, Delft, The Netherlands

10:45-11:00 O22

ELUCIDATING THE IDENTITY AND MUTAGENICITY OF DISINFECTION BY-PRODUCTS ORIGINATING FROM SUNSCREENS IN CHLORINATED SEAWATER SWIMMING POOLS

Tarek Manasfi [1], Michel De Méo [2], Bruno Coulomb [1], Jean-Luc Boudenne [1]

[1] Aix Marseille Univ, CNRS, LCE, Marseille, France
[2] Aix Marseille Univ, CNRS, IRD, Avignon Univ, IMBE, Laboratoire de Mutagénèse Environnementale, Marseille, France

11:00-11:15 O23

THE EFFECTS OF ULTRAVIOLET ON BACTERIAL VIABILITY IN A LABORATORY SWIMMING POOL MODEL

Nikolopoulos G, Birmpa A, Vantarakis A

Department of Public Health, Medical School, Patras, Greece

11:15-11:45 **Coffee break**

11:45-13:45

SESSION 4
HYDROTHERAPY POOLS

Chair: Aurelio Crudeli, Vasiliki Karaouli

11:45-12:15 **KS5**

HOT SPRING WATERS IN POOL: THE PERSONALIZATION OF TREATMENT FROM MFDNA FINGERPRINTING TO NANOTECHNOLOGIES

Vincenzo Romano Spica

Public Health Unit – University of Rome "Foro Italico", Italy

12:15-12:30 O24

MICROBIOLOGICAL QUALITY OF THERMAL WATERS IN GREECE: ASSESSMENT OF 5 YEARS DATA FROM THE CENTRAL PUBLIC HEALTH LABORATORY

Ioanna Spiliopoulou [1], Antonia Theofilou [1], Konstantina Aivalioti [1], Alkiviadis Vatopoulos [1, 2]

[1] Central Public Health Laboratory, Hellenic Center for Disease Control and Prevention, Athens, Greece
[2] Department of Microbiology, National School of Public Health, Athens, Greece

12:30-12:45 O25

THERAPEUTIC POOLS IN REHABILITATION CENTERS IN GREECE THE FILOKTITIS AQUATIC THERAPY MODEL

Efthymia Vagena

Filoktitis Rehabilitation Center, Athens, Greece

12:45-13:00 O26

ASSESSMENT OF AIR AND WATER CONTAMINATION BY DISINFECTION BY-PRODUCTS IN THALASSOTHERAPY CENTERS

Jean-Luc Boudenne, Tarek Manasfi, Bruno Coulomb

Aix Marseille Univ, CNRS, LCE, Marseille, France

13:00-13:15 O27

PRESENCE OF PSEUDOMONAS AERUGINOSA AND CONTROL MEASURES IN THERMAL WATERS

Yuly Andrea Sanchez Londono, Nataly Chivatá López

Escuela Colombiana de Ingeniería "Julio Garavito", Colombia

13:15-13:30 O28

REGISTRATION OF THE LEVEL OF ADJUSTMENT AND FUNCTION IN THE AQUATIC ENVIRONMENT OF CHILDREN WITH CEREBRAL PALSY DURING THE PERIOD 2016-17

Stavropoulou E [1], Antoniadou IM [2], Garaveli M [2], Liris K [2], Nefrou A [2], Pontikakou I [2], Prasinou M [2]

[1] Hellenic Rehabilitation Center for Children (ELEPAP) Athens, Physiotherapy and Therapeutic Programs, Greece
[2] Hellenic Rehabilitation Center for Children (ELEPAP) Athens, Department of Physiotherapy, Greece

13:30-13:45 O29

THE UK POOL WATER ADVISORY GROUP (PWTAG) UPDATED HYDROTHERAPY POOL GUIDELINES

Susanne Lee [1], John Lee [1], Sarah Wratten [2]

[1] Legionella Ltd, UK
[2] Aquatic Therapy Association of Chartered Physiotherapists (ATACP), UK

13:45-14:30 **Lunch**

14:30-16:30

SESSION 5
CHLORINATION BY-PRODUCTS

Chair: Henrik R Andersen, Guglielmina Fantuzzi

14:30-14:45 O30

CHLORINATION BY-PRODUCTS FORMATION IN INDOOR SWIMMING POOLS: DEVELOPMENT OF A PILOT POOL AND ASSOCIATED KINETIC STUDY

L. Tsamba [1], N. Cimetiere [1], P. Humeau [2], D. Wolbert [1], O. Correc [2], P. Le Cloirec [1]

[1] Ecole Nationale Supérieure de Chimie de Rennes, France
[2] Centre Scientifique et Technique du Bâtiment, AQUASIM,Nantes, France

14:45-15:00 O31

OPTIMISED VENTILATION FOR INDOOR SWIMMING POOL BY AN INTELLIGENT REAL-TIME CONTROL SYSTEM

Anuj Sharma [1], Waldo Rosales [1], Emily Ho [1], Sajid Rafique [1], Kevin Feeney [2]

[1] BHR Group, UK
[2] VES Andover Ltd, UK

15:00-15:15 O32

DESTRUCTION OF DBPS AND THEIR PRECURSORS IN SWIMMING POOL WATER BY COMBINED UV-TREATMENT AND OZONATION

Waqas A. Cheema [1, 2], Kamilla M.S. Kaarsholm [1], Henrik R. Andersen [1]

[1] Technical University of Denmark, Bygning Lyngby, Denmark
[2] National University of Sciences & Technology, Islamabad, Pakistan

15:15-15:30 O33

EFFECT OF UV TREATMENT ON DBPS FORMATION IN CHLORINATED SEAWATER SWIMMING POOLS - A LABORATORY STUDY

Waqas A. Cheema [1, 2], Tarek Manasfi [3], Kamilla M. S. Kaarsholm [1], Henrik R. Andersen [1], Jean-Luc Boudenne [3]

[1] Technical University of Denmark, Bygning, Lyngby, Denmark
[2] National University of Sciences & Technology, Islamabad, Pakistan
[3] Aix Marseille Université, CNRS, Marseille, France

15:30-15:45 O34

HALOGENATED DISINFECTION BY-PRODUCTS (DBPs) IN INDOOR SWIMMING POOL

B. İlker Harman [1], Ertaç Tanaçan [2], Ş. Şule Kaplan Bekaroğlu [2], Nuray Ateş [3], Nevzat Ö. Yiğit [2], Tuğba Sardohan Köseoğlu [4], Amer A.S. Kanan [5]

[1] Technical Science Vocational School, Suleyman Demirel University, Isparta, Turkey
[2] Department of Environmental Engineering, Suleyman Demirel University, Isparta, Turkey
[3] Department of Environmental Engineering, Erciyes University, Kayseri 38030, Turkey
[4] Department of Biomedical Engineering, Suleyman Demirel University, Isparta, Turkey
[5] Department of Earth and Environmental Sciences, Al-Quds University, Jerusalem, Palestine

15:45-16:00 O35

COMPARISON OF TRIALOMETHANES IN THE AIR OF TWO INDOOR SWIMMING POOL FACILITIES USING DIFFERENT TYPE OF CHLORINATION AND DIFFERENT TYPES OF WATER

Therese B. Nitter [1], Wolfgang Kampel [2], Kristin V. H. Svendsen [1]

[1] Department of Industrial Economics and Technology Management, Faculty of Economics and Management, Norwegian University of Science and Technology (NTNU), Trondheim, Norway
[2] SIAT - Centre for Sport Facilities and Technology, Department for Civil and Environmental Engineering, Faculty of Engineering, Norwegian University of Science and Technology (NTNU), Trondheim, Norway

16:00-16:15 O36

CRITERIA TO CHOOSE ACTIVATED CARBON THAT CONVERTS MONOCHLORAMINE TO MOLECULAR NITROGEN

Bertram Skibinski [1], Eckhard Worch [2], Wolfgang Uhl [1, 3, 2]

[1] Technische Universität Dresden, Chair of Water Supply Engineering, Dresden, Germany
[2] Technische Universität Dresden, Chair of Hydro Chemistry, Dresden, Germany
[3] Norwegian Institute for Water Research (NIVA), Oslo, Norway

16:15-16:30 O37

MODELLING THE FORMATION AND DEGASSING OF CHLOROFORM IN SWIMMING POOL FACILITIES

Tim Schlosser [1], Lothar Erdinger [1], Morten Møller Klausen [2], Peter Vittrup Christensen [2], Emily Ho [3], Anuj Sharma [3], Waldo Rosales [3], Sajid Rafique [3]

[1] Centre for Infectious Diseases, Med. Microbiology and Hygiene, University of Heidelberg, Germany
[2] DHI, Denmark
[3] BHR Group, UK

16:30-17:00 **Coffee break**

17:00-18:45

SESSION 6
REGULATIONS

Chair: Antonis Papadakis, Georgia Mandilara

17:00-17:15 O38

DEVELOPING A LONG-TERM STRATEGY AND PUBLIC HEALTH SUPPORT SYSTEM FOR IMPROVING HEALTH AND SAFETY AT PUBLIC AQUATIC FACILITIES IN THE UNITED STATES

Beach MJ [1,2], Sackett D [2], Hlavsa MC [1,2]
and the Model Aquatic Health Code (MAHC) Working Group

[1] Centers for Disease Control and Prevention, Atlanta, USA
[2] Council for the Model Aquatic Health Code, Atlanta, USA

17:15-17:30 O39

A PROTOTYPE AND METHOD TO TEST MATERIALS AND TREATMENTS: A "CAVY" SWIMMING POOL

Valeriani Federica, Gianluca Gianfranceschi, Vincenzo Romano Spica

Public Health Unit-University of Rome "Foro Italico", Italy

17:30-17:45 O40

REVIEW OF THE NEW UK GUIDELINES FOR PREVENTING THE RISK OF INFECTION FROM SPA POOLS AND THEIR FUTURE DEVELOPMENT BY PWTAG

John V Lee, Howard Gosling, Susanne Lee

PWTAG, UK, lecture invited by IDEXX

17:45-18:00 O41

UPDATING REVIEW ON ITALIAN SWIMMING POOL REGULATORY FRAMEWORK

Emanuele Ferretti, Lucia Bonadonna

Italian Institute of Health, Department of Environment and Health, Rome, Italy

18:00-18:15 O42

THE EU BIOCIDAL PRODUCT REGULATION 528/2012 AND THE IN SITU GENERATION AF ACTIVE SUBSTANCES

Alexander Reuss

Ospa Swimming Pool Technology - Germany

18:15-18:30 O43

ASSESSMENT OF SWIMMING POOLS IN THE LIGHT OF NEW POOL AND SPA REGULATIONS IN GREECE

Pappa Olga [1], Mandilara Georgia [2], Michalopoulou Diamanto [2], Vatopoulos Alkiviadis [1,2]

[1] Hellenic Centre for Disease Control and Prevention
[2] National School of Public Health, Department of Microbiology

18:30-18:45 O44

UK POOL GUIDANCE – 33 YEARS OF KEEPING IT UP-TO-DATE

Janice Calvert

PWTAG. UK

21:00 **Gala Dinner**

FRIDAY

MAY 5

9:00-10:30

SESSION 7
POOL AND SPA OPEN DISCUSSION: WHERE ARE WE HEADING TO?

Chair: Vincenzo Romano Spica, Christiane Höller

09:00-9:30 **KS6**

POOL AND SPA MANAGEMENT: WHERE ARE WE HEADING TO?

Christiane Höller

Bavarian Health and Food Safety Authority, Oberschleißheim, Germany

09:30-09:45 O45

ACUTE OTITIS EXTERNA, A WATERBORNE INFECTION COMMONLY TRANSMITTED THROUGH POOL & SPA ACTIVITIES – A REVIEW

Nektarios Papapetropoulos

Ear, Nose & Throat Clinic, Penteli Hospital, Athens, Greece

09:45-10:00 O46

SWIMMING POOL & SPA – OVERVIEW OF THE BENEFITS OF WATER TREATMENT AND APPLICATIONS FOR THE HUMAN MUSCULOSKELETAL SYSTEM

Gabriele Karanis [1, 2, 3], Panagiotis Karanis [4, 5]

[1] Orthopedic Department of Qinghai University Hospital Xining, Medical School of Qinghai University Xining, P. R. China
[2] Center for Biomedicine and Infectious Diseases CBID, Xining City, P. R. China
[3] KreiskrankenhausMechernich, Teaching hospital of Bonn University, Germany
[4] State Key Laboratory of Plateau Ecology and Agriculture, Qinghai University, P.R. China
[5] Medical School, University of Cologne, Germany

10:00-10:15 O47

I SPY, I SPY WITH MY LITTLE EYE

Joyce Ribbers [1], Maarten Keuten [2, 3], Thomas van Rompay [1]

[1] University of Twente, Section communication science, Enschede, The Netherlands
[2] Delft University of Technology, Section Sanitary Engineering, Delft, The Netherlands
[3] Hellebrekers Technieken, Nunspeet, The Netherlands

10:15-10:30 O48

DO HYGIENIC RULES AND WATER QUALITY REQUIREMENTS IN SWIMMING POOLS PREVENT DISEASE OUTBREAKS?

M.I.J. Bekendam [1], G. ter Riet [1], J. Schippers [1], F.M. Schets [2]

[1] Amsterdam Medical Center, University of Amsterdam, The Netherlands
[2] National Institute for Public Health and the Environment (RIVM), Bilthoven, The Netherlands

10:30-11:30 **OPEN CONVERSATION FOR A NEW COST PROPOSAL**

11:30-12:00 **AWARD CEREMONY - CLOSING CEREMONY**

Technical Tour:

Boat trip to the nearby island of Nisyros.
Visit to the local thermal waters.

PRESENTATIONS

POSTERS

P1

HIGH PERFORMANCE FILTER MEDIA FOR SINGLE, MULTI-LAYER AND MULTI-MEDIA FILTRATION AT WATER RECLAIMING AND WATER TREATMENT SYSTEMS

Emmerich Matthias

SIGMUND LINDNER GmbH

P2

PHARMACEUTICALS AND ILLICIT DRUGS OF ABUSE IN INDOOR SWIMMING POOL WATERS IN THE EMILIA ROMAGNA REGION, NORTH OF ITALY

Fantuzzi G [1], Aggazzotti G [1], Righi E [1], Predieri G [1], Castiglioni S [2], Riva F [2], Zuccato E [2]

[1] Department of Biomedical, Metabolic and Neural Sciences - University of Modena and Reggio Emilia, Modena, Italy
[2] Department of Environmental Health Sciences, IRCCS-Istituto di Ricerche Farmacologiche "Mario Negri", Milan, Italy

P3

ASSESSING CYANURIC ACID LEVELS FOR CHLORINE STABILIZATION AND EFFECTIVE DISINFECTION IN SWIMMING POOLS

Evi Oikonomidou

Analytical Laboratory of Rhodes, Greece

P4

LEGIONELLA RISK ASSESSMENT AND MANAGEMENT FOR SPA WATERS: THE RECENTLY RELEASED ITALIAN GUIDELINES

Maria Cristina Rota [1], Maria Luisa Ricci [2], Maria Scaturro [2], Enrico Veschetti [3], Mario Cerroni [3], Emanuele Ferretti [3]

[1] Epidemiology Unit, Department of Infectious Diseases
[2] National Reference Laboratory for Legionella, Department of Infectious Diseases
[3] Section of Inland Water Hygiene, Department of Environment and Health
Italian Institute of Health, Rome, Italy

P5

ADVANCED METHODS FOR ASSESSING WATER SAFETY AND QUALITY: APPLICATION ON THERMAL FACILITIES

Stefania Paduano [1], Federica Valeriani [2], Isabella Marchesi [1], Antonella Mansi [3], Carlo Sturani [4], Navneet Saini [1], Annalisa Bargellini [1], Paola Borella [1]

[1] Department of Biomedical, Metabolic and Neural Sciences, Section of Public Health University of Modena and Reggio Emilia, Italy
[2] Department of Movement, Human and Health Sciences, Public Health Unit, University of Rome "Foro Italico", Rome, Italy
[3] INAIL Research Area, Department of Occupational and Environmental Medicine, Epidemiology and Hygiene, Monte Porzio Catone, Rome, Italy
[4] Health Direction, Terme di Sirmione Spa, Brescia, Italy

P6

THE EFFECT OF UV TREATMENT ON HIGHLY POLLUTED AND NORMAL OPERATED SWIMMING POOLS

Spiliotopoulou A [1, 2], Kaarsholm KMS [2], Andersen HR [2]

[1] OxyGuard International A/S, Farum, Denmark
[2] Department of Environmental Engineering, Technical University of Denmark, Lyngby, Denmark

P7

BACTERIOLOGICAL EXAMINATION OF SWIMMING POOLS AND SPA WATER SAMPLES IN NORTHERN GREECE DURING 2011-2016: IS PSEUDOMONAS AERUGINOSA A BETTER POLLUTION INDICATOR?

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It is indeed a great pleasure for us to welcome you to the Kos/Greece 7th International Conference 2017 on Swimming Pool and Spa Waters.

Swimming and bathing are two highly popular activities for all age groups in many countries around the world. Swimming activities are recognized by the World Health Organization as very favorable to human health. The benefits of swimming and bathing to health were, of course, recognized in ancient times. In the Greek island of Kos, in the 5th century B.C., Hippocrates, the father of Medicine, who was also the father of hydrotherapy and balneotherapy, established the Asclepeion, a sacred institution dedicated to medicine, situated next to thermal waters. “Differing curative properties derive from waters with differing contents of various minerals, such as iron, copper, silver, gold or sulfur”, he wrote in his work On Airs, Waters and Places.

In the previous six conferences scientists from diverse countries discussed and proposed key issues related to pool and spa management with a view to ensuring and enhancing physical, microbiological and chemical safety for users.

During your three days in Kos, and particularly in the relaxing facilities of the Kipriotis Village Resort, as participants in the Conference you will have the opportunity to attend and to present scientific papers and hold discussions related to health and pool management. We also hope that you are going to enjoy our social program, the visit to the Kos Asclepeion, the gala dinner at the headquarters and the gardens of the International Hippocrates Foundation and the technical tour to the neighboring volcanic island of Nisyros, also famous for thermal waters.

We wish you a pleasant and fruitful conference and stay in Kos.

On behalf of the Organizing Committee
Prof Athena Mavridou
Assoc. Prof Apostolos Vantarakis

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OPENING CEREMONY:

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PLENARY SPEECH

ASKLLEPIEIA: EARLY EQUIVALENTS OF SANATORIA AND HEALING BATHS

Geroulanos S., MD, PhD

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Asklepieia, the healing temples of the god Asklepios were religious and healing centers. They originated around the sixth c. B.C. By the fourth century they spread all over the Greek mainland and in the next centuries all over the coasts of the Mediterranean Sea. At least 400 Asklepieia functioned without interruption up to the end of the 4th c. A.D., when the Christian emperor Theodosios I (379-395 A.D.) prohibited pagan temples.
The Asklepieion of Epidauros was in Antiquity the biggest and most famous one in Greece. It comprised a huge complex of buildings including temples dedicated to Asklepios, Hygeia, Apollo, Artemis, Aphrodite and other gods. Next to these temples a huge building with at least 360 beds, probably a hospice was erected. In addition to the temples there was the "*abaton*" the incubation site, where patients would go to sleep until the god would visit them in their dream and tell them how they could cure their disease. A stadium, a hippodrome, a small odeon, a library, baths, restaurants and a big theatre for 14'000 spectators, surrounded the temples the hospice and the *abaton.*
Therapy was holistic including all possible ways of treatment not only of the disease but of the person in whole. However, Hydrotherapy was one of the most exercised ways that ended with the construction of huge bath establishments, the so called *balaneia*. In Roman times baths were erected all over the Roman Empire; the most effective one being the Baths of the Aklepieion of Pergamon in Minor Asia. Especially in Greece were hundreds of thermal springs exist, Asklepieia were either built next to these water sources or their healing water was pipelined, sometimes from far away to them. In each Asklepieion a holy spring existed and their water was not only used for cleaning but mainly for therapy. In some of these thermal baths even semigods like Herakles or famous personalities like Aristotle visited and asked for help; Herakles was cured in the baths of Thermopylae, Aristotle was visiting yearly Aedipsos in Euboea.
As the Hippocratic Medicine, born and practiced in the Asklepieia, expanded all over the Western World, the Asklepieia served in the 19th century as models for the early Sanatoria in Europe, however the grandiosity of the Ancient Greek, Roman, Byzantine and Turkish Baths has not yet been reached in the modern West.

ABSTRACTS FROM ORAL PRESENTATIONS

Session I

Microbial and chemical quality in Pool and Spas
Chair: *Jean Luc Boudenne, Maarten Keuten*

KEY SPEECH 1

SWIMMING IN A POOL: HOW HIGH IS THE RISK OF AN INFECTIOUS DISEASE?

Tirodimos I

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There are several communicable diseases that are commonly associated with recreational swimming. Data from Organisms like CDC (Center for Disease Control), show that the most common recreational illness is diarrhea, while parasite *Cryptosporidium* and bacterium *Escherichia coli* account for a great percentage of outbreaks associated with recreational water. Waterborne disease statistics are presented throughout the lecture. We conclude that in order to avoid the above risks, we need to focus: a) in the need for continued vigilance in maintaining water quality (i.e., disinfectant level and pH) and b) in the proper information and training given to swimming users in relevance with health-related behaviors.

ORAL 1

COLONIZATION OF LEGIONELLA SPECIES IN RECREATIONAL WATER SYSTEMS IN CRETE: A 28 YEAR SURVEILLANCE STUDY

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Aims
From July 1998 to October 2016, ECDC have been reported 74 cases of Travel-associated Legionnaires' disease (TALD), associated with travelers and personnel in hotels, at the Prefecture of Heraklion, Crete, Greece. The aims of the present study are: a) to study the frequency and severity of contamination of water distribution systems (particularly those of recreation systems) by *Legionella* spp, b) to identify the risk factors associated with *Legionella* colonization, c) to identify the *Legionella* spp. in water samples and d) to evaluate the implementation of Water Safety Plans (WSP) to limit *Legionella* colonization.

Methods
The Local Public Health Authorities of the Prefecture of Heraklion, Crete, Greece, examined 47 water distribution systems, associated either with TALD (37 hotels and one water park) or with an active surveillance program (five hotels, three ferries and one children's camp), at the aforementioned Prefecture.
A total of 108 inspections (Mean: 2.4 inspections/site; Min: 1/site; Max:8/site; Std: 1.9), were carried out, analyzing 1151 environmental samples from hot /cold water distribution systems, cooling towers, decorative fountain ponds, showers, rain bird rotary nozzles, treated wastewater. Data on water temperature, pH, chlorine concentration, disinfection methodology, and hotel star rating, number of rooms/beds, presence of water safely plan, etc, were recorded. In 11 of the 37 hotels, checklists including 42 scored items concerning their water supply system were filled in. Laboratory analysis was performed according to ISO 11731 and ISO 11731-2. Isolated colonies were identified using an agglutination test (SLIDEX® Legionella-Kit, Biomérieux, Craponne, France), which allows the discrimination of *L. pneumophila* serogroup 1 from serogroups 2–14 and L. *anisa*, while for the exact detection of each serogroup individual latex polyclonal reagents were used (Pro-lab, Richmond Hill, Canada). From 2010 onwards, MALDI Biotyper (Microflex LT MALDI-TOF mass spectrometer) (Bruker Daltonics, Leipzig, Germany) was used for the identification of individual Legionella colonies against the microbial database (v3.1.2.0). All identifications were evaluated according to the manufacturer's scoring scheme. A second inspection was performed at a hotel when Legionella count was higher than 10000 c.f.u./L in at least one sample or between 1000 - 10000 c.f.u./L in more than two samples or between 1000 - 10000 c.f.u./L in at least one sample in concordance with an aerobic count of higher than 100000 c.f.u./ml. The statistical analysis was performed using Epi-Info 2000 version 7.2.0.1 (Centers for Disease Control and Prevention, Atlanta, GA) and SPSS for Windows release 23 software (SPSS Inc., Chicago, IL).

Results

During the 28 year study a total of 74 human cases of Legionnaires diseases were recorded (Mean: 1.9/site; Min: 1/site; Max: 13/site; Std: 2.5). Of the 1151 water samples collected, 211 (18.3%) were associated with accommodation in recreation areas and spas; in particular: 28 (2.4%) samples were collected from swimming pools, seven (7; 0.6%) from spa, five (5; 0.4%) from jacuzzi, 105 (9.1%) from showers next to swimming pools, two (2; 0.2%) from shower heads, and 10(0.9%) from showers at spas. Furthermore, in certain circumstances, the areas next to the swimming pools were investigated. 54 samples were collected from the latter sites, which corresponded to: 17 (1.5%) samples from rain bird rotary nozzles, 10 (0,9%) from treated wastewater, 25 (2.2%) from water spectacles such as waterfalls and fountains, while two (2; 3.7%) samples from garden soil. A total of 246 (21,4%) out of the 1151 samples were positive (>50 cfu/L). Of the samples that were strictly associated with recreational waters, 32/211 (15.2%) were detected as positive. In particular, *Legionella* was isolated from swimming pool showers (16/105; 1.4%), in 13/35 (28.9%) hotels, rain bird rotary nozzles (6; 0.5%) in 5/10 (50%) hotels, treated wastewater (3/10; 0.3%) in 2/6 (33.3%) hotels, swimming pool water (3/28; 0.3%) in 2/17 (11.8%) hotels, decorative fountain (2/25; 0.2%) in 2/9 (22.2%) hotels, spa (1/7; 0.08%) in 1/5 (20%) hotels, spa showers (1/10; 0.08%) in 1/4 (25%) hotels. *Legionella* was not detected in shower heads, in water from jacuzzi and in garden soil. All results among with the isolated and identified *Legionella* species are summarized in Table 1. The risk of having a human contamination was higher in small municipalities and in the absence of a fully developed water supply network, equipped with a regular chlorination system (OR=1.5; RR=1.4; p=0.01; x^2=6.3). Even when focusing just on recreational waters, the stasitical significance still remained high (OR=2.6; RR=2.2; p=0.03; x^2=4.4). A statisticaly significant result (OR=11.5; RR=9.8; p=0.03; x^2=4.3) was calculated when an innovative disinfection method (stabilized chlorine dioxide; copper ions) was used at a hotel, for the concomitant use of a solar water heater, at temperatures out of range (OR=2.9; RR=2.2; p<0.05; x^2=5.8), for the absence of an automated chlorination system (OR=1.12; RR=1.1; p=0.9; x^2: 0), chlorine concentration less than 0.2 ppm (RR=5.88; p<0.001; OR=8.9; x^2=14.6), Star classification of the hotel (<4) (RR=3.36; p<0.001; OR=4.2; x^2=17.7) and absence of water safety plan (WSP) implementation (RR=2.33; p<0.05; OR=2.66; x^2=4). No relative risk was calculated when taking under consideration the number of beds (>200) (RR=0.26; p<0.001; OR=0.2; x^2=14.5), the number of rooms (>80) (RR=0.34; p<0.001; OR=0.2; x^2=9.7) and groundwater as a source of water supply (RR: 0.27; p< 0.001; OR=0.21; x^2 =12.5). On the contrary no statistically significance was calculated for cold water (temperature >25°C), non 12-month hotel operation and water pH ≥7.8. Out of the 11 hotels, four (36.4%) received score B (relatively satisfactory) while 7 (63,7%) got score C (unsatisfactory) (Figure 1).

Conclusions

Legionella colonization was recorded in a large number of water supply systems, posing in danger the health of both, personnel and tourists. A number of factors related to the construction, maintenance, management, disinfection of water supply systems and the requirement to implement a WSP contributed to the presence of Legionella colonization. The relative risk of Legionella colonization was lesser in swimming pools and in spa, due to increased surveillance and implementation of proper chlorination procedures, contrary to the showers of swimming pools.

Table 1: Legionella serogroups and species isolated and identified from recreational waters. (Pos: positive. L. p.: *Legionella pneumophila*.)

Legionella serogroups/ species	**Swimming pool**		**Spa**		**Swimming pool shower**		**Spa shower**		**Rain bird rotary nozzles**		**Decoration fountain**		**Treated wastewater**	
	pos. samples/ hotel	range (cfu/L)	pos. samples/ hotel	range (cfu/L)	pos. samples/ hotel	range (cfu/L)	pos. samples/ hotel	range (cfu/L)	pos. samples/ hotel	range (cfu/L)	pos. samples/ hotel	range (cfu/L)	pos. samples/ hotel	range (cfu/L)
L.p. sg 1	1/1	700			2/2	350-1150								
L.p. sg 2					2/2	150-550								
L.p. sg 3									2/2	50-650				
L.p. sg 8									1/1	300				
L.p. sg 14			1/1	50	3/3	150-100,000	1/1	150						
L.p. sg 2-15					4/3	30.000-100,000			3/3	100,000				
anisa	1/1	19,500			6/5	750-100,000					1/1	2,500		
erythra			1/1	650	1/1	400								
taurinensis	1/1	26,000			1/1	50								
species											1/1	1,000	3/2	1,000

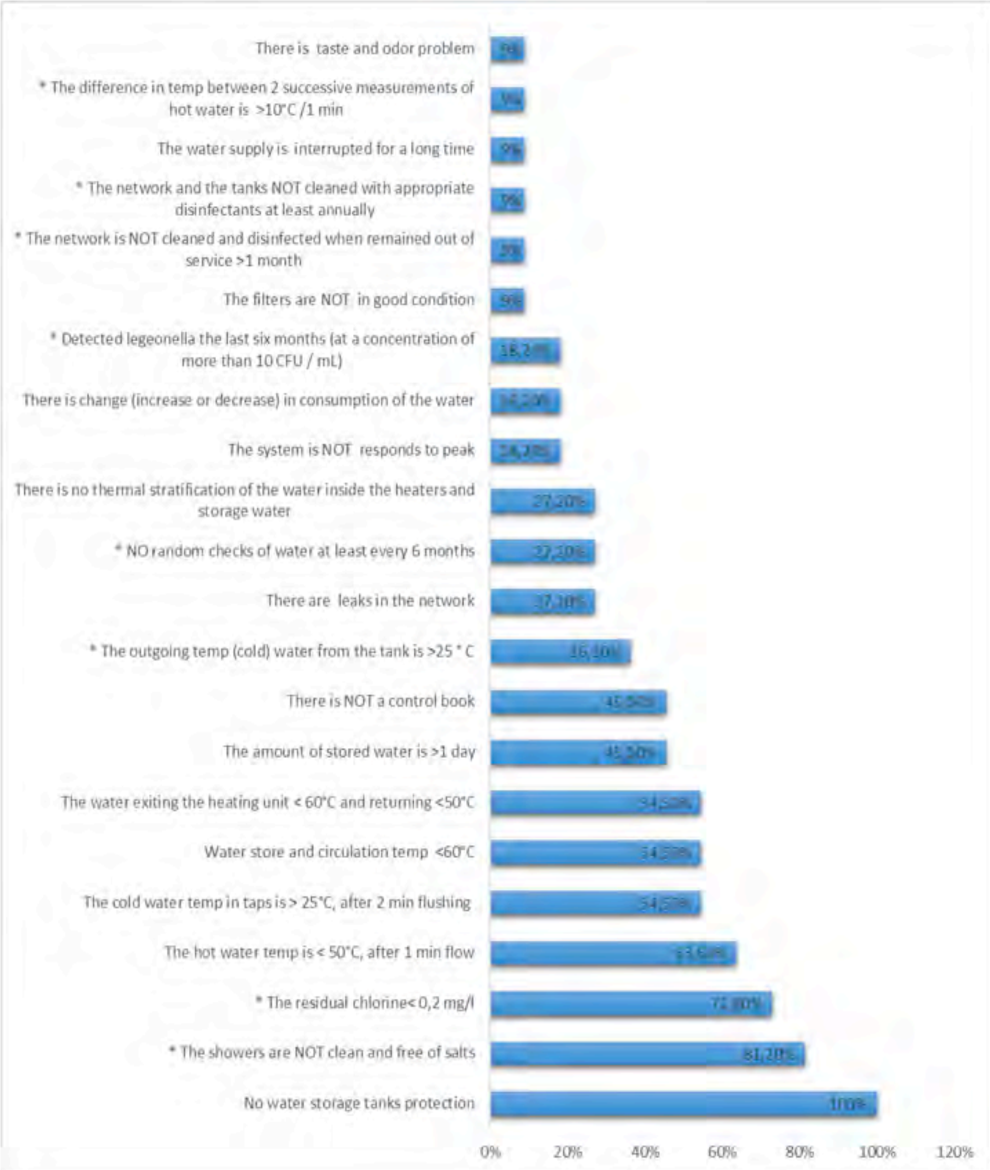

Figure 1: Findings from the completion of the checklists at the 11 hotels. *: designates a critical item.

KEY SPEECH 2

PARASITES AND THE CREATION OF BIOFILM IN POOL ESTABLISHMENTS

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Among the documented waterborne outbreaks caused by protozoan parasites were characterized by multiple modes of transmission, including untreated water supplies, contaminated water sources, failures in treatment processing, contamination of reservoirs or post treatment contamination. In the period 2011-2017 about 14% (55) of the reported outbreaks, the source of infection was identified as recreational water, primarily due to contamination with *Cryptosporidium* spp. (48 outbreaks), with the recreational water source usually being a public/community swimming pool. Swimming pools have become major recreation facilities for leisure and sports in cities and towns across the world, but the standard guidelines are not adhered to because little is known about the parasites in the pools and the possible risks involved. Biofilms are ecosystems that are formed mainly by bacteria, creating a favourable micro-environment that can support the survival and growth of other micro-organisms, f.e. FLA (Free Living Amoeba) and *Cryptosporidium*. Biofilms may serve as an environmental reservoir for Parasites in aquatic environments and may be responsible for the occurrence of sporadic outbreaks. There is a need to better understand Parasites behaviour in biofilm environments, especially in relation to swimming pool systems and to investigate and address the question whether Parasites captured within biofilms can utilise this nutrient rich micro-environment to survive and multiply. The speech focuses on the possible role of biofilms as a habitat for Parasites, highlighting in particular role of biofilms in swimming pool water systems and address the question, if parasites captured withing biofilms can utilize the nutrient micro-environment to survive, propagate and can cause in infections to the final users.

ORAL2

FREE-LIVING AMOEBAE AND VIRUSES IN PUBLIC SWIMMING POOLS AND RECREATIONAL WHIRLPOOLS

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Aims

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 at higher disinfectant concentrations. In this context, in an attempt to clarify the risk of exposure when swimming or bathing in recreational facilities, we investigated the presence of free-living amoebae in parallel with that of human enteric viruses (adenovirus, norovirus and enterovirus) in swimming pools and whirlpools located in the Rome area (Italy). In addiction, the occurrence of two non-enteric virus (human papillomavirus and human polyomavirus) was also explored. Heterotrophic bacteria, *Pseudomonas aeruginosa* and *Staphylococcus aureus* were even considered and chlorine residual and pH were measured.

Methods

Qualitative analyses were performed for free-living amoebae, isolated on Non- nutrient and by microscopic examination. Molecular techniques (PCR and sequencing) were utilized to confirm identification at genus level. Molecular analyses (PCR, sequencing and Real-time PCR assay) were used to detect viruses. Heterotrophic bacteria, *P. aeruginosa* were detected according to the ISO 6222 and Pseudalert/Quanti-Tray, respectively; Baird-Parker enumeration of *S. aureus* was performed with the membrane filtration technique. Chlorine residual and pH were measured by a multi-parameter photometer.

Results

Free living amoebae were found in 46% of swimming pool samples and in 38% of whirlpools examined. None of the enteric viruses tested were detected, whilst papillomaviruses and polyomaviruses were detected in 64% of the samples. The levels of chlorine residual could represent a guarantee for maintaining the good bacteriological quality of water. Nevertheless, *P. aeruginosa* was found in 62% of whirlpools water samples and bacterial counts were in the order of magnitude of 10^2 cfu/mL whilst *S. aureus* was not detected.

Conclusions

Due to the numerous reported cases and outbreaks, risk infection associated with recreational swimming pools and whirlpools represents a serious concern of public health since many years. These environments are often a prime colonization area for potentially harmful microbes able to survive and grow in slime layers of pipes and taps as well as in the water bulk.

Diseases caused by free living amoebae are frequently transmitted while swimming or bathing in chlorinated water. Their robust stage of cyst let them particularly resistant to disinfection and environmental stress. Free-living amoebae belonging to the genus *Acanthamoeba* are able to cause severe sight threatening keratitis. Outbreaks due to human enteric viruses such as adenovirus, norovirus, and enterovirus are very often associated to swimming pools cause of inadequate disinfection or following faecal accidents. However, the extent of viral spread under non-epidemic conditions has been investigated only by few studies. This study could be a first step for this topic. At the moment, the suggested recreational water quality standards are bacterial indicators such as intestinal enterococci and *Escherichia coli*, but it is well known the lack of a consistent correlation between these indicator organisms and viral pathogens and free living protozoa. 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.

ORAL3

CLINICALLY-RELEVANT FUNGI ON SURFACES AND IN WATER IN AN INDOOR SWIMMING POOL FACILITY

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[3] National Institute for Public Health and the Environment, Centre for Zoonoses and Environmental Microbiology, Bilthoven, the Netherlands
[4]Delft University of Technology, the Netherlands
[5] Utrecht University, Faculty of Veterinary Medicine, Institute for Risk Assessment Sciences, the Netherlands

Aims
Of all the estimated millions of fungal species, only approximately 600 species are known as obligate or opportunistic pathogens. Human mycoses vary from relatively innocent, superficial infections in otherwise healthy people (e.g. ringworm and onychomycosis) to life-threatening invasive deep and disseminated infections (e.g. candidiasis, aspergillosis) especially in immunocompromised individuals. Most human mycoses are caused by opportunistic pathogens with a common occurrence in the environment. In public facilities like swimming pools, people can get exposed to pathogens. The risk of acquiring infections in swimming pools is often associated with microbial contamination of the water due to faecal matter, non-faecal human shedding, and inadequate disinfection. Direct contact with contaminated surfaces and inhalation of air are also potential exposure routes to pathogens. Studies on fungal contamination in swimming pool environments have demonstrated the common occurrence of fungi that cause infections in humans. In this study, the fungal population in water and on surfaces in an indoor swimming pool facility was investigated, focusing on the occurrence of clinically-relevant fungal species. Clinically-relevant fungal species in this study are defined as fungal species which are known to have caused infection and/or disease in humans. The purpose of this study was to broaden the knowledge on the fungal community in the swimming pool environment, in relation to a better understanding of the exposure routes for fungal infections in swimming pools. The diversity of fungal species was assessed by applying different sampling methods and culture media. Fungal identification to the genus level and where possible to the species level was based on ITS sequencing.

Methods
The sampling was carried out in one swimming pool facility in the Netherlands, comprising of 6 different separate pools (pool A - F). In total, 16 surface samples (from floors next to the pools, floors in the dressing room area, benches, ladder, diving platforms, walls and a flexibeam) and 6 water samples were taken. Water samples were collected using 20 L plastic containers. Sample volumes of 2 L, 1 L and 2x0.5 L of pool water were filtered through 0.45 µm pore size membrane filters. Filters were placed on different (semi)-selective culture media: Malt Extract Agar (MEA), Pentachloronitrobenzene Agar with Rose Bengal (PCNB), Erythritol-Chloramphenicol Agar (ECA), and Sabouraud Dextrose Agar (SDA). All plates were incubated in the dark: PCNB, ECA, and SDA

plates at 25°C and MEA plates both at 25°C and at 40°C. Colonies were counted after 7 days. Surface samples were collected using RODAC plates and swabs. RODAC plates with the same culture media as used for water samples, were pressed on the surfaces for 10 seconds and incubated as described above. Swabs were washed in 20 mL of 0.1% peptone saline and the extracted solution was also cultured on the same culture media.

Five loose colonies were selected from each medium per sample for fungal species identification. Selected colonies were sub-cultured on Oatmeal Agar (OA) slants, incubated at 25°C for 3 days and stored at 10°C for later use. Fungal DNA from the lysed mycelium of the isolated colonies was extracted using Chelex 100. Amplification of the internal transcribed spacer (ITS) gene using primers ITS1/ITS5 and ITS 4 followed by sequencing was used to identify the fungal genus and/or species.

Results

Fungi were detected in pool water of all the investigated pools. The fungal counts in water samples ranged between 0-20 CFU/100 mL with the highest count in water from pool D. Fungi were detected in most surface samples, with the number of colonies on RODAC plates ranging between 0-2.5 CFUs/cm² and from swabs ranging between 0-5.8 CFUs/cm². The highest counts were observed in samples from the floors next to pool A and on the flexibeam. Only one colony could be grown from the wall in the swim hall and no fungi could be grown from the floor in the shower (the dressing room area). Higher fungal counts were observed at sites where people walk with bare feet (pathways and pool sides) compared to sites like benches and walls. The fungal counts from surfaces using RODAC plates and swabs were not significantly different.

The use of different culture media resulted in detection of a large diversity of fungal species. From the 357 isolates from water and surfaces, 79 species and species complexes were identified; 42 of these were clinically-relevant species. More clinically-relevant fungal species were detected among isolates from surfaces (71.4%, 30/42) compared to water (59.5%, 25/42). *Phialophora oxyspora* (13.7%), *Phoma* spp. (12.3%), and *Cladosporium cladosporioides* complex (4.5%) were the most frequently isolated clinically-relevant fungi which were all isolated from pool water as well as from surfaces. Other clinically-relevant species identified in this study were *Aspergillus fumigatus* complex, *Scedosporium boydii*, *Candida tropicalis*, *Rhinocladiella similis*, and *Trematosphaeria grisea*.

Conclusions

Fungi, including clinically-relevant species, occur widely in the swimming pool environment.

The differences in fungal counts obtained with RODAC plates and swabs were not significant, however RODAC plates are preferred for practical reasons. The use of different culture media allowed the detection of different groups of clinically-relevant fungi and contributed to insight in the diversity of fungal populations in the swimming pools.

The presence of clinically-relevant fungi in swimming pools, particularly at sites where people walk bare feet, suggests a possible risk of infection and warrants further research into preventive measures and disinfection needs to reduce fungal contamination and limit the infection risk.

ORAL 4

5-YEAR MICROBIOLOGICAL SURVEILLANCE OF SWIMMING POOL WATER IN SW GREECE

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Aims
A variety of microorganisms can be found in swimming pools, which may be introduced in the pool water in several ways. A swimming pool is a body of water of limited size contained in a holding structure. This water is generally of potable quality and is treated with additional disinfectants (chlorine compounds, ozone). Although modern swimming pools have a re-circulating system so that the water can be filtered and disinfected effectively, relevant research studies, show that neither hi-tech systems nor disinfectants can prevent the colonization of the pool water with microorganisms. The swimmers are sensitive to infections mainly to the: skin (i.e dermatitis), eye (i.e conjunctivitis), ear (i.e external ear infections) and rarely hepatitis A, gastroenteritis, parasites etc. In a 5-year period (January 2012–March 2017), the microbiological and chemical quality of swimming pool waters was investigated in Patras, SW Greece.

Methods
Aseptic standard techniques were used during sampling. Samples collected during time of maximum swimmer's load. In total, 678 water samples were collected. For each facility, a sampling location was chosen close to the pool outlet as a representative of water circulated in the pool. All water samples were analyzed by membrane filtration. Water samples from 6 pools were analysed for microbes according to European legislation (total coliforms, Escherichia coli, and total mesophilic bacteria count at 37 °C) as well as for *Pseudomonas aeruginosa* and *Staphylococcus aureus* using appropriate ISO protocols.

Results
Analysis of 678 pool samples was performed from 2012 till 2017 from six swimming pools in Patras. From all the samples, 38.2% found to be positive for total coliforms, 9.4% positive for *Escherichia coli*, 87.8 % positive for total mesophilic bacteria count at 37 °C, 16.5 % positive for *Pseudomonas aeruginosa* and 48.4 % positive for *Staphylococcus aureus*. According to legislation total mesophilic bacteria counts at 37 °C were in a percentage of 13.9% higher than legislation, total coliforms was in a percentage of 9.7% higher than legislation as well as the rest of microorganisms depart with the percentages mentioned above.

Conclusions
Swimming pools have been increasingly popular and possible maintenance failures might cause public health problems. This study confirms the importance of regular maintenance of swimming

pool. There is a need to improve disinfection and cleaning procedures, with consideration given to the different uses and daily bather loads of each pool type. There is also a need to monitor water quality and to increase users' knowledge and awareness of the risks.

ORAL 5

ABUNDANCE OF ANTIBIOTIC RESISTANT BACTERIA IN THERAPY POOLS AND SURROUNDING SURFACES

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Introduction

The number of patients colonized with antibiotic resistant bacteria is increasing in health care facilities. Often there exists a great uncertainty how to handle these patients. Because transmission of antibiotic resistant bacteria is feared the patients are excluded frequently from important therapies. There are therapies that cause a larger release of bacteria. These include e.g. therapies that are performed in a swimming pool. Hydrotherapy is a non-invasive and beneficial treatment used for patients with different diseases. Data from the literature in other countries suggest that the existing water disinfection is not always sufficient to kill all released bacteria. Bacterial contamination can occur either due to deficiencies in water treatment or due to colonization of the pool equipment. When bacteria are attached to surfaces, basin or equipment alike, they may be more resistant against disinfectants than when in suspension. If the pool water is not disinfected properly, it may also infect the bathers. Immunocompromised patients are particularly susceptible to be infected with pathogens (including antibiotic resistant bacteria) via the mucous membranes and via penetration of bathing water into auditory canals and the nasopharynx. Yet, to our knowledge, no information exists about the public health impact of such therapy pools in the dissemination of antibiotic resistant bacteria. In order to be able to better estimate the distribution and the associated transmission risk in clinical therapy pools we performed a study on this topic.

Aims

The main objective of the project is to investigate the occurrence of antibiotic resistant bacteria in water of therapy pools, in filters, balance tanks and on surrounding surfaces. Factors contributing to their occurrence will be discussed with regard to details in pool water treatment and disinfection, number of patients entering the pools and usage of the pools for other purposes. Finally, we hope to derive recommendations for the management of patients colonized with antibiotic resistant bacteria in hydrotherapy pools.

Methods

Eleven pre-selected therapy pools in Bavaria are sampled (pool water, filter water, balance tank water and filter backwash water). The water samples are concentrated by membrane-filtration through 0.45 micrometer-pore-size membrane filters. Antibiotic resistant bacteria are isolated by placing the filters on different selective media. The isolates are identified by MALDI-TOF-MS and tested for antimicrobial susceptibility by BD Phoenix™ according to manufacturer's instructions. In addition to the water samples, samples from the surrounding surfaces (especially sanitary areas and pool equipment) are taken with swabs and also examined for antibiotic resistant bacteria. Typical water quality parameters (free chlorine, combined chlorine, THMs etc., according to DIN 19643-1) are also determined from all water samples. Furthermore a standardized questionnaire was developed and given to the facilities operating the therapy pools to document the technical details of the pool, their water treatment, cleaning procedures, frequency and duration of pool usage.

Results

The number of bathers/patients using the pool clearly differs between the sampled facilities, ranging from < 50 patients per year to 35,000 patients per year. So far 65 % of the samples from 11 different therapy pools have been collected. Antibiotic resistant bacteria were found in the water and surface samples collected. So far we obtained 53 isolates from water samples and 170 isolates from surrounding surfaces, with *Pseudomonas* spp. (22%) and *Staphylococcus* spp. (18%) as the most common genera. The preliminary results indicate a correlation of the number of isolates in water samples with the number of patients in combination with deficiencies in water treatment (high concentrations of bound chlorine for example). Until now, only in one health care facility isolates could be obtained directly from the pool water. This clinic has not only the highest number of visitors but also problems with the water treatment. A correlation between the high number of isolates from surrounding surfaces and the high number of bathers can be observed. As the cleaning intervals of the pool and the surrounding of the pool are very similar between the different health care facilities, there is no detectable correlation between the number of isolates and the cleaning interval. The highest number of isolates was obtained from barefoot-areas (39) and floor cleaning equipment (34). Sampling is still ongoing and will be finished in April 2016. Further results will be available soon.

Conclusions

Despite the reduction of antibiotic resistant bacteria due to water treatment and disinfection, some are still present in the water of therapy pools and on surfaces. Especially in therapy pools antibiotic resistant bacteria are potentially transferred from patients to the therapy pool environment. There they can potentially persist and infect other patients and staff alike.

ORAL 6

ADSORBABLE ORGANIC HALIDES (AOX) FORMATION POTENTIAL IN SWIMMING POOLS

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Introduction
Swimming pool water has natural organic matter (NOM) from filling water and human excretions (body fluids). Human inputs such as urine, sweat, saliva, skin and hair are the main body excretions to the swimming pool water [1]. To date, chlorine and bromine based disinfectants are still the most common use for inactivation of microbial pathogens in swimming pool water [2]. However, the reaction of disinfectant with various precursors (natural organic matter, and body excretions) may cause the formation of undesirable disinfection by-products (DBPs) [1, 2]. Organohalogen DBPs can be measured as a bulk parameter using adsorbable organic halides (AOX). The objective of this study was to determine the role of human body fluids using body fluids analogs (BFAs) in AOX formation. The effects of contact time, chlorine dose, and pH on AOX potential formation were studied.

Methods
BFAs were prepared to simulate the human body fluids that are excreted to swimming pool water continuously from bathers. The formation potentials experiments were conducted at 27°C, 1 mg/L total organic carbon (TOC) (obtained from BFA solution) and 50 mg/L initial chlorine dose.

Results
At 27 °C and pH of 7.0 the AOX formations for contact time of 5 and 10 days were 385 µg/L and 326 µg/L, respectively.

Conclusions
Like as DBPs formation in the swimming pools, the change of pH and contacts time affect in a different and variable manner of AOX concentrations. A large fraction of the DBPs has not been identified in swimming pool and the unknown DBPs can make up 40-60% of the total load of DBPs. However, these unknown compounds can be more toxic than known DBPs on human health. In this context, AOX measurements in swimming pools may give a key information about amount of halogenated organic compounds

Acknowledgment
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ORAL 7

500 DAYS OF SWIMMERS: VARIABILITY OF THE CHEMICAL WATER QUALITY OF SWIMMING POOL WATERS FROM THE BEGINNING

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Aims

The aim of this study was to temporally monitor the chemical water quality of two newly built, filled and opened swimming pools. Disinfection by-products (DBPs), as well as other chemical and physical parameters, were analysed for 16 months, with investigations beginning prior to the opening of the facility.

Methods

Two individual swimming pools at one location in Perth, Western Australia were investigated over 16 months (approximately 35 samples analysed). Pool A (20 m outdoor/covered leisure pool) was treated with chlorine gas and was equipped with ultraviolet treatment. Pool B (50 m outdoor lap pool) was treated with chlorine gas in combination with cyanuric acid. Sampling was conducted at the same time of day on each sampling event. Free and total chlorine equivalent concentrations, pH, temperature, conductivity and dissolved oxygen were measured at the pool. Water samples were collected in amber bottles (no headspace) and the oxidant residual was quenched (10% excess) before they were stored at 4^{0}C. Samples were analysed within 48 hours for non-purgeable organic carbon (NPOC), total nitrogen (TN) and 39 individual disinfection by-products (DBPs); 4 trihalomethanes (THMs), 9 haloacetic acids (HAAs), 6 haloacetonitriles, 7 halonitomethanes (HNMs), 3 haloacetamides (HAAms), 4 haloketones (HKs) and 6 haloacetaldehydes (HAAls).

Results

Considering Pool A, of the 37 DBPs investigated, eight were detected in all samples, 4 were detected in at least 75% of the samples, 4 were found in between 50-75% of samples, whilst 10 were detected in less than half of the samples. Thirteen DBPs were not detected in Pool A. Pool B showed fewer DBPs detected than in Pool A, with only six DBPs detected in all samples. Four DBPs were detected in over 75% of the samples analysed, whilst two were found in more than half the samples. Ten were detected in less than 50% of the samples, whilst seventeen were not detected in Pool B. Considering average molar concentrations, the different classes of DBPs in order of highest to lowest concentrations were HAAs > HAAls > THMs > HANs > HKs > HNMs > HAAms for Pool A and HAAs > HANs > THMs > HAAls > HKs > HNMs > HAAms for Pool B. Minimum, maximum and average concentrations for the different classes of DBPs (in µg/L), as well as NPOC and TN (in mg/L), are shown in **Table 1**. Filling water was analysed periodically and was found to contain low concentrations of some DBPs. Excluding brominated DBPs, the mains water was eliminated as a source of DBPs in the swimming pools. In terms of DBPs which were detected in more than 95% of all samples analysed, for Pool A, chloral hydrate (CH), dichloroacetonitrile (DCAN), chloroform, dichlorobromomethane, chloro-, dichloro-, trichloro- and bromochloro-acetic acid (CAA, DCAA, TCAA and BCAA, respectively) were detected in all samples, with 1,1,1-trichloropropanone (1,1,1-TCP) detected in 96% of samples. Similarly, for Pool B, CH, DCAN, chloroform, bromodichloromethane, DCAA and TCAA were detected in all samples and 1,1,1-TCP in 96% of samples analysed. **Figure 1** shows the trends of concentrations over time, of Pool A, for some of the DBPs detected in greater than 95% of samples analysed, as well as TN and NPOC. A steady decrease of NPOC between days 40 (30 mg/L) and 244 (2.8 mg/L) may be attributed to the change of season (summer to winter) and hence frequency of use. Similarly, a steady increase was observed from day 244 until the end of the study (up to 23 mg/L), highlighting the seasonal trend of NPOC. Initially, TN concentrations steadily increased (up to 17 mg/L), likely due to the input and consequent build-up of bather derived compounds which are generally high in nitrogen. TN concentrations were found to generally decrease until day 244, which can be explained by (i) lower swimmer attendance and hence lower nitrogen input via bathers, and (ii) more free chlorine being available to react with built up nitrogen which can escape the pool as nitrogen gas. Concentrations generally increased from day 244 until the end of the study, which is likely due to higher bather loads resulting from seasonal trends. Although a maximum concentration was observed much sooner for chloroform, both chloroform and CH exhibited a similar trend, an initial increase followed by a steady decrease until approximately day 300, in which then increasing concentrations were observed. Considering all samples, maximum concentrations of 19 µg/L for CH and 39 µg/L for chloroform were observed. The chlorinated HAAs (TCAA, DCAA and CAA), as well as BCAA, all followed a similar trend. After an initial peak in concentrations (4.8-25 mg/L) at day 9, an exponential decrease was observed. A repeating trend (smaller increase followed by an exponential decrease) was observed to begin at day 244. Although some impact from seasonal trends may occur, these trends are potentially a result of leaching and subsequent oxidation of building materials, which would logically occur soon after construction. The second repeating trend (day 244) may also be a result of building material leaching, as maintenance work occurred at approximately this time. Chlorinated HAAs measured during the initial opening of the pool (up to 26 mg/L for DCAA) were over four times higher in concentration than any maximum previously reported in swimming pools, 6.8 mg/L (Kanan, 2010). Similarly, CH concentrations observed in this study (244-3181 µg/L) were generally up to nine times higher than those previously reported, up to 400 µg/L (Carter et al., 2015; Daiber et al., 2016; Lee et al., 2010; Manasfi et al., 2016; Serrano et al., 2011; Yeh et al., 2014; Zhang et al., 2015). Further research into the possible formation of DBPs from chlorination of components which may be leached from pool building materials is underway.

Conclusions

The chemical water quality of two newly built, filled and opened swimming pools was measured for 16 months. Most DBPs showed an increase in concentration soon after the swimming pool opening, after which concentrations generally decreased. Some DBPs as well as NPOC, showed seasonal trends: lower concentrations in winter and higher concentrations in summer. Extremely high concentrations of HAAs (particularly CAA, DCAA, TCAA and BCAA) and CH were observed throughout the study, with maximum concentrations observed soon after opening. Further studies to investigate these results are underway.

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Table 1: Summary of disinfection by-products, non-purgeable organic carbon and total nitrogen concentrations measured in Pools A and B. Presented as “average (minimum-maximum)” as calculated by mass.

DBP Class	Units	Pool A	Pool B
Haloketones[a]	µg/L	19 (1.13-164)	10 (3.77-33)*
Haloacetaldehydes[b]	µg/L	1571 (247-3217)	55 (2.74-151)
Haloacetonitriles[c]	µg/L	53 (3.08-274)	46 (2.12-150)
Halonitromethanes[d]	µg/L	2.76 (0.31-9.44)*	4.45 (0.21-46)
Haloacetamides[e]	µg/L	<LOD	<LOD
Trihalomethanes[f]	µg/L	253 (30-4402)	44 (8.88-102)
Haloacetic Acids[g]	µg/L	19270 (2092-35994)	884 (342-4458)
Non-Purgeable Organic Carbon	mg/L	14 (2.77-30)	6.55 (1.72-21)
Total Nitrogen	mg/L	3.33 (0.13-16)	7.24 (4.45-21)

(a) Refers to the sum of chloro-, 1,1-dichloro-, 1,3-dichloro- and 1,1,1-trichloro-propanone; **(b)** Refers to the sum of dibromo-, bromochloro-, bromodichloro-, dibromochloro-, trichloro- and tribromo-acetaldehyde; **(c)** Refers to the sum of chloro-, bromo-, dichloro-, dibromo-, bromochloro- and trichloro-actetonitrile; **(d)** Refers to the sum of dichloro-, dibromo-, bromochloro-, bromodichloro-, dibromochloro-, trichloro- and tribromo-nitromethane; **(e)** Refers to the sum of dichloro-, dibromo- and trichloro-acetamide; **(f)** Refers to the sum of trichloro-, bromodichloro-, dibromochloro- and tribromo-methane; **(g)** Refers to the sum of chloro-, bromo-, dichloro-, dibromo-, bromochloro-, bromodichloro-, dibromochloro-, trichloro- and tribromo-acetic acid; **(*)** Indicates that in some samples, minimum concentrations were below the limit of detection; **(<LOD)**: Below the limit of detection.

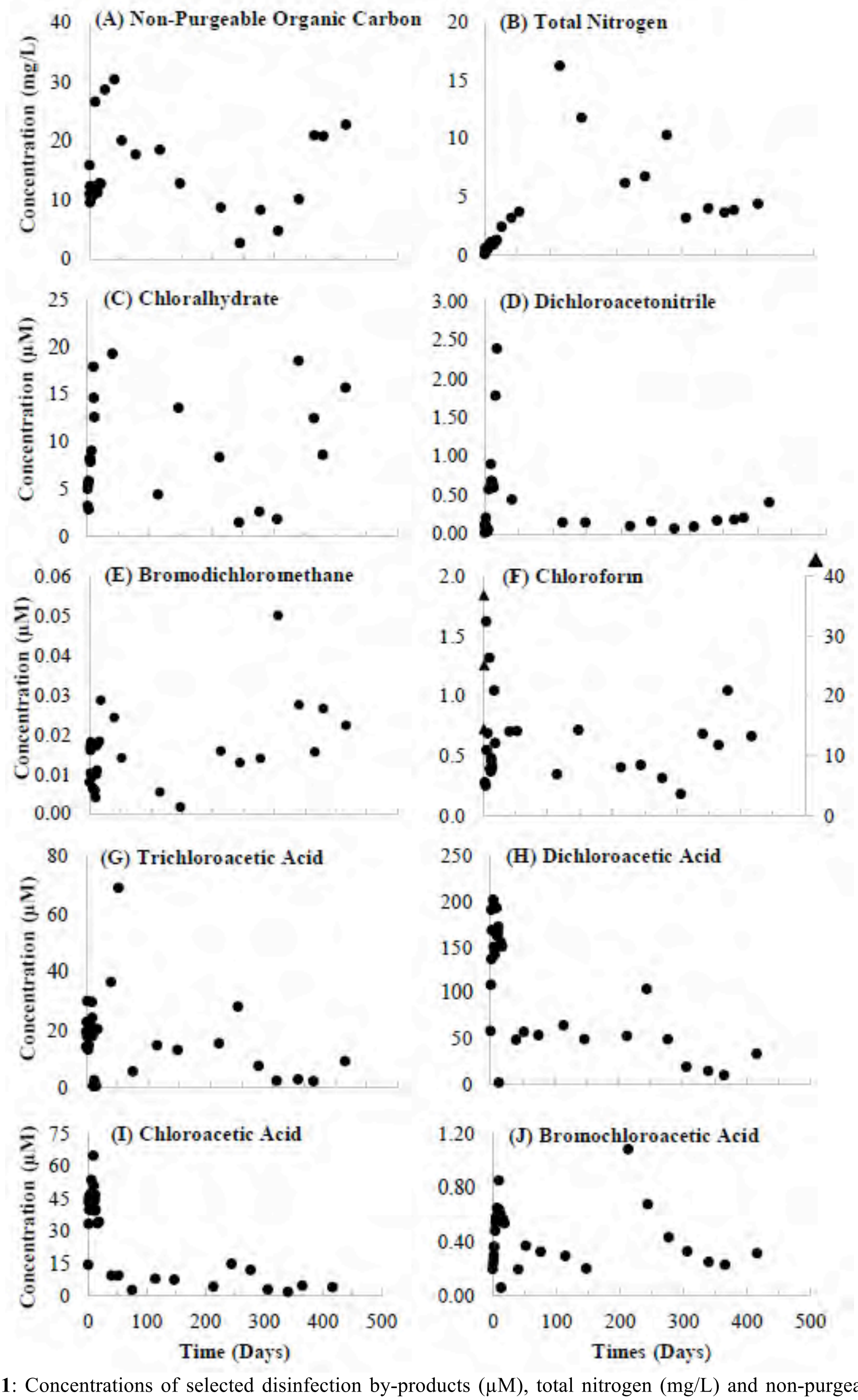

Figure 1: Concentrations of selected disinfection by-products (µM), total nitrogen (mg/L) and non-purgeable organic carbon (mg/L) in Pool A over time. Time zero is the day prior to swimming pool opening. Concentrations of chloroform were one order of magnitude higher until day two and are designated a secondary axis (▲).

ORAL 8

OCCURRENCE OF PHARMACEUTICALS AND UV FILTERS IN SWIMMING POOLS AND SPAS

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Aims
The risk of potential accumulation of pharmaceuticals and personal care products (PPCPs) in swimming pool systems exists as a consequence of inefficient water treatment and water recirculation. Conventional water treatment processes such as coagulation-flocculation and sand filtration have proven to be inefficient in removing trace levels of pharmaceuticals (Vieno et al., 2007). PPCPs are non-volatile, their reaction with chlorine is slow and, thus, they are likely to remain in the swimming pool water (Weng et al., 2014). From the above, the need emerges of deepening knowledge on the occurrence of specific pharmaceuticals and UV filters in swimming pools, to highlight any existing pattern linking their occurrence to the type of pools and the type of water treatment applied. This study focussed on pharmaceuticals and UV filters with an elevated potential to enter swimming pool water such as those used in topical formulations applied to the skin or mucous membranes to treat ailments, including but not limited to creams, foams, gels, lotions, and ointments. The list of target pharmaceuticals additionally includes some diuretics and other pharmaceuticals with high excretion rates in urine.

Methods
Water samples from 17 pools in 2 hotels and 6 sport centres located in Catalonia, Spain were analysed for pharmaceuticals and UV filters. In total, 51 water samples were collected over three different days. The 17 pools consisted of 8 outdoor pools, 6 indoor pools and 3 spas. The water treatment in these pools consisted of the combinations of coagulation (in 9 pools), sand filters (in all 17 pools), followed by disinfection either by sodium hypochlorite (in 11 pools), sodium bromide (in 1 pool) or UV and salt electrolysis (in 3 pools). The samples were collected in sterile amber PET bottles (500 mL and 1000 mL) and quenched by adding ascorbic acid to prevent the reaction of target compounds with free chlorine present in the pool water. Water samples were filtered through 0.45 µm PVDF membrane filters (pharmaceuticals) and nylon membrane filters (UV filters) and then stored in the dark at -20°C until analysis. The analyses of 32 pharmaceuticals and 14 UV filters in the water

samples was carried out with solid phase extraction followed by liquid chromatography-tandem mass spectrometry (LC/MS-MS) as described in Gros et al. (2006) and Gago-Ferrero et al. (2013), respectively.

Results

At least one pharmaceutical and UV filter was detected in 96% (49/51) and 100% (51/51) of all the samples, respectively. Only 10 out of 32 pharmaceuticals (atenolol, carbamazepine, hydrochlorothiazide, metronidazole, ofloxacin, sulfamethoxazole, acetaminophen, ibuprofen, ketoprofen and phenazone) were measured higher than limit of quantification (LOQ) while 11 out of 14 UV filters (BP1, BP2, BP3, BP8, THB, 4DHB, 4MBC, OD-PABA, 1HBT, MeBT and DMeBT) were detected >LOQ. The pharmaceutical that was detected at the highest concentration was hydrochlorothiazide (a thiazide diuretic), at 904 ng/L, while the most frequently detected pharmaceutical was carbamazepine (an anticonvulsant and psychiatric drug) (53%). The UV filter that was detected at the highest concentration was 4-metylbenzylidene camphor (4MBC) (69.3 ng/L) whereas the most frequently detected UV filter was benzotriazole (1HBT) (59%). Figure 1 shows the occurrence of 10 pharmaceuticals and 11 UV filters categorized by pool water treatment. The lowest occurrence of pharmaceuticals was observed in the pools applying sand filters followed by disinfection by sodium hypochlorite (13.3%). While based on type of pools, spas showed the highest occurrence (36.7%) compared to the other type of pools. Pool water treated with a combination of coagulation, sand filters, UV and salt electrolysis had the lowest occurrence of UV filters (14.1%) whereas UV filters were detected with the highest frequency in spas (32.3%).

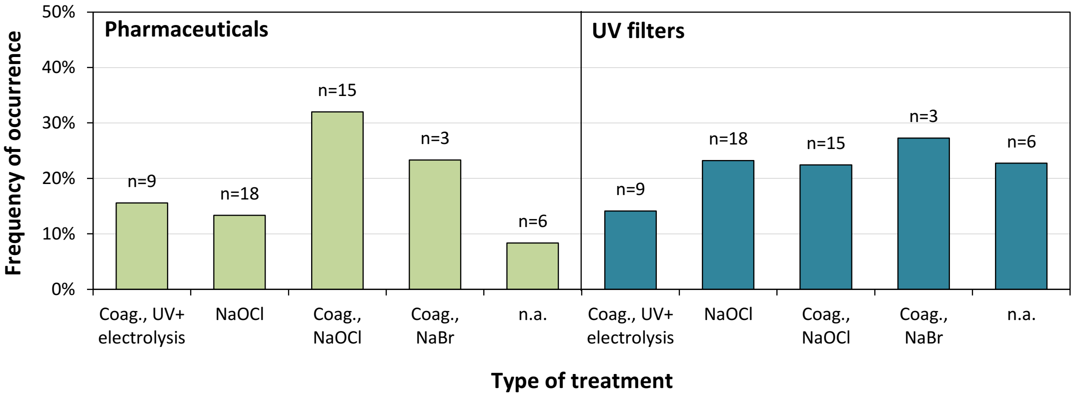

Figure 1 Occurrence of pharmaceutical compounds categorized by treatment. (n: number of samples). Sand filtration was present in all the pools.

Conclusions

PPCPs were widely detected in pool water, mostly at low concentrations. The accumulation of persistent PPCPs is likely to occur in the swimming pools where simple sand filtration followed by disinfection (and water recirculation) is the common treatment applied. With regards to the application of alternative water treatment to remove PPCPs, further studies are required to establish whether health impacts of PPCPs can justify higher investment and operational cost.

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SESSION II - PART 1

Risk Assessment in Pool and Spas

CHAIR: *Lucia Bonadonna, Michael Beach*

KEY SPEECH 3

RISK ASSESSMENT IN POOLS AND SPA FACILITIES

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Introduction
Pool is a structure designed to hold water to enable swimming or other activities in water. The use of swimming pools exposes users to microbiological and chemical risks. With the increasing public access to diiferent kind of pools it is very important to conduct risk assessment and accordingly implement effective risk management**.**

Aims
This article will highlight the importance of health risks assessment related to pools in order to define critical points for the different groups of people and various causes of diseases.

Data Sources
Review of available literature and relevant published studies

Results
Health risks assessment in pools and spa facilities depend on various factors such as: types of pools, their maintenance, characteristics of people who use pools.
Pool waters are used by people of different age groups and different health status. With the use of recreational waters the risk of recreational water illnesses (RWI) is associated. RWIs include different infections: gastrointestinal (diarrhea is the most common), skin, ear, respiratory, eye and wound infections. These diseases are caused by microbiological and chemical contaminants that can be found in this category of water. The most important microbiological contaminants are: *Cryptosporidium*, *Giardia, Shigella, norovirus, E. coli* O157, *Legionella*, while the most important chemical contaminants are disinfection byproducts (DBP). These contaminants are introduced into the body by ingestion, inhalation or direct contact through the skin.The main risks are: poor water quality in swimming pools, inadequate disinfection, inadequate ventilation system, swallowing water, swim duration and frequency, behaviour of consumers (shower before entering the pool, wearing goggles).

Conclusions
Many different risks are associated with the use of water in swimming pools and it is necessary to work on risk assessment and define risk management in defining pools.

ORAL 9

HYGIENIC SITUATION IN NATURAL SWIMMIMG POOL (NSP)

Bruns S

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NSP are considered to be an option for new bathing facilities. The water in the NSP is treated biologically and physically without any kind of chemical disinfection. The author will try to present a complete picture of the new generation of public pools.

1. How can it work?
2. What are the basics of these regulations?
3. What are the achieved numbers of *E. coli*, *Enterococci* and *Pseudomonas aeruginosa* in NSPs during the last 10 years
4. What is the situation regarding Giardia and *Cryptosporidium*?
5. Could it be possible that the *in situ* part of the natural water treatment has some advantages in terms of eliminating these parameters, and what are the potential actors to eliminate these species inside the bathing water?
6. What are the major problems of NSP and where do we have to focus our attention on to constantly improve the hygienic and limnological situation?

The author Stefan Bruns is a member of the regulation team FLL and technical designer of public pools, spas and water features worldwide. Polyplan is always interested in further research programs with universities and other institutes. The introduction into all of these subjects can only present (or give) a first impression and is meant as an invitation to you as a hygienic expert to participate in this new technology.

ORAL 10

EVALUATION OF THE IMPLEMENTATION OF THE PUBLIC HEALTH SURVEILLANCE PROGRAM OF SWIMMING POOLS OF THE NORTHERN REGION OF PORTUGAL (2015 and 2016)

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Aims
To present the results of the activities developed by the professionals working in the Public Health Units (PHU), regarding the performance of the Public Health Surveillance Program of Swimming Pools, in the Northern Region of Portugal, in 2015-2016.

Methods
Each year, the Public Health Department (PHD) of the Northern Region of Portugal (which serves a population of almost 4 million people) elaborates and publicizes to all 24 PHU the directives and goals regarding the annual Public Health Surveillance Program of Swimming Pools, for implementation. Besides this Program, are also disclosed: the Pool Register Template, which must be completed and returned to the PHU; the Sanitary Registration Book (SRB) model, to be disclosed to pool managers; the Communication of Alert Situations form, which is intended to be a way of articulating between pool managers and PHU in situations of improper water; and the Occurrences in Swimming Pools form, also authored by the PHD, intended to constitute itself as a channel of communication of accidents and illnesses in users or workers (fecal accidents, vomiting, blood in tanks, and other situations). Every six months, the PHD sent to each PHU an Excel® table to fill, to evaluate all activities that were developed and to identify constrains in its execution. The Excel® table is already pre-filled with the designation of all tanks and pools – either Type 1 (public) or Type 2 (semi-public) – located in the geographic area of each PHU. The main variables that integrate the table are: use of Sanitary Registration Book by pool managers; inspections made; water sampling; manager's compliance with control programs; epidemiological surveys carried out; closure of pool tanks by Health Authorities; intervention in case of complaints and report of occurrences in swimming pools. All the activities under evaluation are subject of an annual report.

Results
In 2016 were identified 791 swimming-pools in the Northern Region (160 more than in 2015), corresponding to 1199 water tanks (324 more than in 2015). Of all the tanks registered in 2016, 527 had annual operations and 672 seasonal operations; 751 were indoor, 443 were outdoor and 5 were convertible. The average number of users in 2016 was 101 947 people/ day. The use rate of the SRB by pool managers increased from 2015 to 2016, surpassing the PHD regional objective (70%). During the first semester of 2016, 22.3 % of Type 1 and 81.4% of Type 2 pools were inspected – in this case, the year objective to inspect, at least, 50% of Type 2 pools was already accomplished (the same was observed in 2015). In 2015 and 2015, an average of 738 microbiological samples and 421 chemical samples were made within the Public Health Surveillance Program of Swimming Pools (which was less than previewed). In the first semester of 2016, 75.6% of Type 1 pools and 51.2% of Type 2 pools

complied with the analytical aspect of its control programs (goal for 2016, respectively, of 100% and 30%). In spite of these results, both revealed an increase when compared to 2015. No epidemiologic survey related to the use of pools was made in 2015 and 2016. Until December 1st, 2016, Health Authorities closed 17 pool tanks because of bad water quality (during 2015, 40 tanks were shut down for the same motive). In 2016, a total of 10 complaints were received, mainly due to poor cleaning conditions, water temperature or 'excess chlorine'. In 2015, there were 11 complaints of the same content. Forty eight occurrences in swimming pools were reported in 2016, 90% of which related with the presence of vomit or feces in the tanks. In 2015, two of the fifty six occurrences were fatal accidents (one caused by a fall on the pavement, and the other after a dive in the pool).

Conclusions

2014 was the initial year of implementation of the Public Health Surveillance Program of Swimming Pools, so 2015 was the year of consolidation. The use rate of the Sanitary Registration Book by pools' managers was considered low. Failure to comply was due to the existence of their own records. A short term goal of the PHD is to create a digital SRB. The number of inspections by professionals of the PHU was far below expectations. This situation was probably justified by the high discrepancy in the number of pools per PHU (there are PHU with only 7 swimming pools to inspect in their geographical area, and other with 70 swimming pools), the volume of work in each PHU and the availability of human and material resources. Fewer water samples than expected were done, essentially due to the lack of human resources. The main constraint associated with managers' failure to carry out water analyzes was due to the lack of legislation, which leads to fewer mandatory interventions by Health Authorities. It is considered that there was an underreporting of information on occurrences in swimming pools, mainly because it is a recent obligation, and there is little familiarity with it, either by the PHU professionals or by the pools' managers. On the other hand, the voluntary communication of a pool accident or an illness can give managers a sense of fear of the probable consequences. In general, the balance between 2015 and 2016 is considered positive, in the involvement and growth of professionals in the search for solutions, in a closer relationship with pools' managers, in the identification of difficulties experienced (locally and regionally) and in the provision of safe equipments.

ORAL 11

THE CHEMICAL AND MICROBIOLOGICAL ASPECT OF SWIMMING POOLS IN KOS

Trakossa I

IONLAB, Kos. Greece

Introduction

Kos, the island of Hippocrates, attracts every season a large number of tourists. The summer season starts at the end of April and usually lasts until the end of October. The total number of swimming pools on the island of Kos exceeds 200. The Hotels in Kos usually use two types of water, either only fresh water or a combination of fresh water and sea water. Depending on what type of water hotels use for their swimming pool, conductivity parameter varies. The disinfectants commonly used are sodium hypochlorite or chlorine dioxide. Ozon or UV lamps are not yet used as disinfectants.

Materials and Methods

The current Greek Sanitary Decree for the quality of the pool water imposes a minimum of chemical and microbiological tests according to the season - outdoor temperature and the amount of people/visitors using the swimming pool. Parameters typically analyzed are pH, conductivity; free chlorine, alkalinity as well as Biological Oxygen Demand, Chemical Oxygen Demand and Salinity (for swimming pools that contain sea water), Total Aerobic Counts at 22 & 37 ^{o}C, Total Coliforms, Feacal Coliforms (or *Escherichia coli).* Even though they are not included at the Sanitary Decree and because of WHO Guidelines, most Greek laboratories perform additional microbiological analyses for Intestinal Enterococci and *Pseudomonas aeruginosa*. Sampling procedures are carried out according to ISO 19458:2006 §4.4.3 and ISO 5667-1:2006 as well as ISO 5667-3:2012. Sampling begins at the end of April and lasts until the mid of October. For our research we collected data from April 2015 until October 2016. In the Laboratory (IONLAB), laboratory methods were applied according to the standard methods ISO and APHA.

Results

The total number of pool samples analyzed between April 2015 and October 2016, were more than 300. Samples are categorized according to the type of water and the sampling location. In 2015 85% of samples consisted of fresh water while 15% of sea water. As for the sampling location in 2015 90% of samples were taken from the southern area of kos island, while 10% from the northern area. Similar phenomena appeared in 2016.

Statistical Analysis

According to the statistical study for the chemical and microbiological parameters analyzed in 2015 and 2016 the results are as follows:

Table 1: Results for measurements of pH, Conductivity and Free Chlorine

Season Period	**Parameters**								
	pH			**Conductivity (µS / cm)**			**Free Chlorine (mg / lit)**		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
May – June 2015	7	8.2	7.7	1228	3925	2431	0.2	1.9	1.06
July – August 2015	3.6	8.2	7.3	916	30900	6155	0	4.5	0.8
September – October 2015	3.6	8.4	7.2	1722	31200	9562	0.02	3.1	0.97
May 2016	6.9	8.5	7.8	870	12620	3149	0	5.5	1.3
June 2016	7.1	8.6	7.7	1138	38500	4674	0	6.3	1.7
July 2016	6.5	8.7	7.5	1954	53700	7602	0.01	4.6	0.7
August 2016	6.6	8.7	7.5	1205	47500	7077	0.01	4.1	0.8
September 2016	4.1	8.5	7.4	1420	56300	7527	0.01	4.0	0.9
October 2016	6.6	8.5	7.2	1381	55800	8599	0.04	3.5	0.7

From the total number of samples in 2015 we can conclude that approximately 19% had a pH value less than 7.2 while 8% had a value over 8.2. This phenomenon depends on whether the disinfectant used is itself alkaline or acidic, as well as on the temperature and season time the sample was taken.
25% of samples in 2015 had a conductivity value above 4000 µS/cm, while 75% had a conductivity value less than 4000 µS / cm. For the free chlorine the statistics show that approximately 60% of the samples had free chlorine less than 1 mg / lit, while 9% had over 2 mg / lit. If sodium hypochlorite is used as a disinfectant, then due to high outside temperature, the result is that it evaporates easily. On the other hand, if chlorine dioxide is used, it is more drastic and effective but it has a short life time. (Table 1). Regarding the microbiological parameters, 1% (1/80) of samples was detected positive with Intestinal Enterococci, but none with *Pseudomonas aeruginosa* and or *Escherichia coli.* (Table 2). In 2016 the variety of the samples is greater so the results show that 18% of the total samples had a pH value less than 7.2, and 7% had a pH value over 8.2. (Table 1). For the conductivity measured for the same months 38% of the total samples had a conductivity value over 4000 µS / cm, while 62% were in normal range. Of course some of the samples due to high salinity are expected to have an increased conductivity. Regarding free chlorine, like in 2015, the results show that 67% of the total samples analyzed in 2016 appeared to have free chlorine less than 1 mg / lit, 18% had over 2 mg / lit. (Table 1). Apart from the chemical aspect, the microbiological analysis showed the following: Less than 1% (1/240) of samples was detected positive with *Escherichia coli* and Faecal Coliform and none with *Pseudomonas aeruginosa* or Intestinal Enterococci. As for 2015 for all samples Total Aerobic Counts were ≤ 200 cfus / ml. (Table 2)

Table 2: Results of the microbiological tests

Year / Microbiological Parameter	2015		2016	
	Samples			
	Detected positive	Detected negative	Detected positive	Detected negative
Escherichia coli	0	80	1	239
Faecal Coliforms	0	80	1	239
Intestinal Enterococci	1	79	0	240
Pseudomonas aeruginosa	0	80	0	240
Total Aerobic Counts	5 with ≤ 200 cfus / ml	75 with 0 cfu / ml	13 with ≤ 200 cfus / ml	227 with 0 cfu / ml

Conclusions

All in all we can conclude that maintaining and controlling the swimming pools is one thing, but the most important one is to monitor those swimming pools periodically, because weather conditions and several types of contaminants can alter the same sample throughout the season. On the other hand, throughout the season there is a constant variance among the parameters. Nevertheless, the most important thing is that there were nearly none bacteria present in the swimming pools. This phenomenon can be eliminated if swimming pools are monitored at a regular basis.

ORAL 12

ASSESSMENT OF INDOOR HOTEL SWIMMING POOLS IN A SKI RESORT AREA IN GREECE

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Aims
Parnassos area is a popular winter vacations tourist destination with ski resorts. Luxurious hotels provide, among other facilities, internal heated swimming pools which are very popular to the hotel residents. The purpose of the current study was to evaluate the operational and sanitary conditions and to assess the level of compliance with the current Greek regulations of these internal heated swimming pools. The entertaining impact of the swimming pools usage is also a part of this study.

Methods
In this study, 13 internal swimming pools were sampled. The pools were geographically dispersed in the entire Parnassos area. They represent the 97% of the total hotel indoor swimming pools of this area. For the assessment of each swimming pool, a "swimming pool checklist" was prepared. The checklist included 30 control points. Each point reflected structural, functional and sanitary aspects of the pool, e.g. the water circulation rate, the filter condition and the bathing load. Measurements

were carried out in situ (pH, total & free chlorine using a portable photometer, water & air temperature). Samples were transferred to the laboratory for microbiological tests. The samples were tested according to the current Greek legislation where the recommended upper acceptable limits are: THC < 200 cfu/ml, Total coliforms < 15 cfu/100ml and E. coli < 1 cfu/100ml, Nevertheless additional microbiological parameters were included according to WHO Guidelines national E.U. countries regulations and the literature, that was Staphylococcus *aureus*, *Staphylococcus spp*., Enterococci, *Legionella pneumonophila*, *Legionella spp*, *Pseudomonas aeruginosa*, and adenoviruses.

Results

For all the swimming pools examined, construction incompliance to the regulation was not recorded. The pools' sanitary conditions were also according to current legislative standards. Nevertheless deficient operation of the circulation and insufficient refining system was recorded. Although the circulation time indicated by the regulation was up to 4 hours, this limit was violated in 12 out of 13 pools. Poor safety measures for the prevention of drowning and injury were recorded in 38% of the pools

In 10 out of 13 swimming pools were found hyper-chlorinated with free chlorine concentrations 2,2-3,95 mg/l , (LOD 3.95 mg/l) when the Greek regulation limit was (0,4-0,7 mg/l / 0,4-0,7 ppm). Total chlorine measurements revealed concentrations as high as 3,5 – 5,4 mg/l. The swimming pools' pH ranged from 5,8 to 7,0 (Greek regulation limit 7,2 to 8,2). The separation degree of the hypochlorious acid to its components (H + and OCl^-), which is formed when the chlorine is added as a disinfectant in the water, depends on the pH and the temperature. When chlorination is used, the pH control is a crucial factor in order to achieve proper disinfection of the water. When the pH of the water is below 6.0 the separation degree is decreased, while in case of pH 8.0 or higher, the chlorine is considered substantially ineffective. The oxidizing action of chlorine is inversely proportional to the pH value, making the chlorine in water with pH 7,2 5 times more active than the chlorine in water with pH 8. The Greek regulation regarding chlorine disinfection determines thresholds for the concentration of residual chlorine only and not for the relationship with the waters' pH. The water temperature in all cases was 20 ^oC - 28 ^oC while the internal ambient temperature was 22 ^oC - 25 ^oC. Increased temperature enhances hypochlorious acid breakdown, the unpleasant chlorine smell on the indoor pool, breathlessness and eyes sting It should be noted that, depending on the type of incoming mains water and the disinfectant used, the pool water may need adjustment to the ideal pH range using chemical treatment. As for the microbiological tests, *E.coli* and *Staphylococcus spp*. counts were 3 – 112 cfus/100 ml and 1 – 118 cfus/100 ml respectively in 4 swimming pools. In 8 swimming pools, TVCs at 37^{o}C were 3 - 300 cfu/ml. 6 out og 13 pools violated the TVCs maximum value of 100 cfus/ ml of the Greek regulations. 4 out of 8 swimming pools had total coliforms counts 6– 112 cfus/100 ml. Adenoviruses were detected in one of these swimming pools. *Legionella pneumonophila*, *Legionella spp*, *S. aureus*, Enterococci and *Pseudomonas aeroginusa* were no detected. The management of 12 out of the 13 swimming pools didn't provide data of microbiological monitoring of the pool water.

Conclusions

In 61, 55% of the swimming pools, violation of the imperative values for microbiological indicators defined by the Greek regulation and /or WHO Guidelines (Total Coliforms, *E.coli*, Staphylococcus) were recorded after the laboratory tests. Poor safety measures for the prevention of drowning and injury were recorded in 38% of the pools.

SESSION II - PART 2

Risk Assessment in Pool and Spas

CHAIR: *Emanuele Ferretti, Janice Calvert*

ORAL 13

IMMEDIATE CLOSURES AND VIOLATIONS IDENTIFIED DURING ROUTINE INSPECTIONS OF PUBLIC AQUATIC FACILITIES – NETWORK FOR AQUATIC FACILITY INSPECTION SURVEILLANCE, UNITED STATES, 2013

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Aims

Aquatic facility–associated illnesses and injuries in the United States include disease outbreaks of infectious or chemical etiology, drowning, and pool chemical–associated health events (e.g., respiratory distress or burns). These conditions affect persons of all ages, particularly young children, and can lead to disability or even death. A total of 650 aquatic facility–associated outbreaks have been reported to the U.S. Centers for Disease Control and Prevention (CDC) for 1978–2012. During 1999–2010, drownings resulted in approximately 4,000 deaths each year in the United States. Drowning is the leading cause of injury deaths in children ages 1–4 years, and approximately half of fatal drownings in this age group occur in swimming pools. During 2003–2012, pool chemical–associated health events resulted in an estimated 3,000–5,000 visits to U.S. emergency departments each year, and approximately half of the patients were ages <18 years. In August 2014, CDC released the Model Aquatic Health Code (MAHC), national guidance that can be adopted voluntarily by state and local jurisdictions to minimize the risk for illness and injury at public aquatic facilities (physical places that contain one or more aquatic venues [e.g., a pool or hot tub/spa] and support infrastructure [e.g., chemical storage area]).

Methods

The Network for Aquatic Facility Inspection Surveillance (NAFIS) was established by CDC in 2013. The primary objective of NAFIS is to enable public health authorities to evaluate whether adoption of MAHC elements minimizes the risk for illness and injury at public aquatic facilities. The secondary objective is to demonstrate the utility of inspection data and thus expand their use by state and local environmental health programs to monitor the operation and maintenance of public aquatic facilities and inform program planning, implementation, and evaluation. NAFIS receives aquatic facility inspection data collected by environmental health practitioners when assessing the operation and maintenance of public aquatic facilities. This report presents inspection data that were reported by 16 public health agencies in five states (Arizona, California, Florida, New York, and Texas) and focuses on 15 MAHC elements deemed critical to minimizing the risk for illness and injury associated with aquatic facilities (e.g., disinfection to prevent transmission of infectious pathogens, safety equipment to rescue distressed bathers, and pool chemical safety). Although these data (the first and most recent that are available) are not nationally representative, 15.7% of the estimated 309,000 U.S. public aquatic venues are located in the 16 reporting jurisdictions.

Results

During 2013, environmental health practitioners in the 16 reporting NAFIS jurisdictions conducted 84,187 routine inspections of 48,632 public aquatic venues. Of the 84,187 routine inspection records for individual aquatic venues, 78.5% (66,098) included data on immediate closure; 12.3% (8,118) of routine inspections resulted in immediate closure because of at least one identified violation that represented a serious threat to public health. Disinfectant concentration violations were identified during 11.9% (7,662/64,580) of routine inspections, representing risk for aquatic facility–associated outbreaks of infectious etiology. Safety equipment violations were identified during 12.7% (7,845/61,648) of routine inspections, representing risk for drowning. Pool chemical safety violations were identified during 4.6% (471/10,264) of routine inspections, representing risk for pool chemical–associated health events.

Conclusions

Routine inspections frequently resulted in immediate closure and identified violations of inspection items corresponding to 15 MAHC elements critical to protecting public health, highlighting the need to improve operation and maintenance of U.S. public aquatic facilities. These findings also underscore the public health function that code enforcement, conducted by environmental health practitioners, has in preventing illness and injury at public aquatic facilities. Findings from the routine analyses of aquatic facility inspection data can inform program planning, implementation, and evaluation. At the state and local level, these inspection data can be used to identify aquatic facilities and venues in need of more frequent inspections and to select topics to cover in training for aquatic facility operators. At the national level, these data can be used to evaluate whether the adoption of MAHC elements minimizes the risk for aquatic facility–associated illness and injury. These findings also can be used to prioritize revisions or updates to the MAHC. To optimize the collection and analysis of aquatic facility inspection data and thus application of findings, environmental health practitioners and epidemiologists need to collaborate extensively to identify public aquatic facility code elements deemed critical to protecting public health and determine the best way to assess and document compliance during inspections.

ORAL 14

DYNAMIC MODELLING OF SWIMMING POOL WATER QUALITY

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Aims

Research in pool water chemistry over the last decade using advanced online monitoring techniques has shown that the water quality in swimming pools is highly variable both within a single hour, from day to day and over a week. This temporal variation in water quality is a result of several interacting factors, e.g. bather load, fresh water intake, chemical reactions with the added disinfectant and the applied water treatment technologies. Due to the variations in bather load, both the addition of anthropogenic pollutants and the disturbance of the pool surface show large fluctuations on a daily basis. The result is a system that exhibits dynamic behavior on a time scale of hours. Thus, simple steady-state mass balance considerations are not able to describe the resulting water quality. Furthermore, the dynamic behavior of the system makes it difficult to predict the necessary capacity and efficiency of water treatment technology implemented to achieve improvements in water quality. To describe the dynamics of the water quality in the pool system a time dependent model with variable boundary conditions is required. A generic time dependent model has been developed in the FP7 R4SME project INTELLIPOOL. The model has been developed for technology design purposes in order to evaluate the effect of a number of water treatment technologies on the pool water composition. Using this approach, the dominating factors on water quality (THM, combined chlorine, particle concentration etc.) are identified and quantified. Furthermore, the model can be used to evaluate the effect of introducing, removing or upgrading water treatment technologies, thereby making it possible to carry out a virtual system optimization.

Methods

A pool system model is established to describe the chemical and physical processes in the pool. The model includes chemical dosing of chlorine and acid, fresh water intake, water evaporation, degassing of volatile species, addition of anthropogenic pollutants, DBP formation from dissolved and particulate components, and treatment of the recirculation flow by filtration, UV treatment and forced DBP stripping. The model is based on a set of ordinary differential equations describing the time derivatives of the individual processes combined with a mass balance equation and chemical stoichiometry. Time dependent boundary conditions are applied to obtain a dynamic behavior of the water quality parameters. The model is calibrated using measured time-series of bather load, chlorine consumption, acid addition, particle concentration, DOC, dissolved inorganic species (chloride, bicarbonate, ammonium, nitrate, chlorate), Total-N, THM and combined chlorine from a newly build Swedish public pool with a high degree of online water quality monitoring.

Results

Using an independent set of measurements, the model is validated. The model results show good correlation with the measured data and it is found capable of estimating the daily dynamics of species such as THM and combined chlorine. The measurements of THM concentration is observed to oscillate on a daily basis with a maximum before opening in the morning and a minimum just before closing in the evening. The model is able to describe this behavior as a balance between THM production in the pool water and natural degassing from the pool surface. During opening hours the degassing prevails due to the increased surface area and surface mixing caused by the bathers. During night where the degassing is low, the production dominates and the concentration increases. For the combined chlorine concentration the dynamic is inverted. During opening hours, an increase in the concentration, whereas a decrease during night time is observed. The model is able to describe this behavior as a balance between production, degassing and removal in the water treatment system (UV). Due to the addition of anthropogenic pollutants during opening hours the production dominates, whereas the absence of such addition during night results in a decrease. Particle concentration measurements show a strong dependence on the bather load and thus an increase during opening hours followed by decrease during closing hours. By virtually changing the process technology set-up, hydraulic capacity and efficiency of the applied water treatment technologies, the dynamic system effects are quantified.

Conclusions

A time dependent model of a pool system was developed and calibrated using a number of online and grabs sample measurements from a Swedish public pool. The model is able to describe the dynamic behavior observed for water quality species such as THM, combined chlorine, particles and DOC. Furthermore, modelled steady-state levels of the less dynamic species, e.g. chloride, chlorate and nitrate were in agreement with the measurements.

ORAL 15

ASSESSMENT OF MICROBIOLOGICAL QUALITY OF WATER FROM SWIMMING POOLS IN GREECE: 7 YEARS DATA FROM THE CENTRAL PUBLIC HEALTH LABORATORY.

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Aims
Swimming pools are used by millions of people seeking recreation and health benefits. Proper management and disinfection are vital in order to minimize possible negative health impacts. Furthermore, samples of swimming pool waters should be monitored at appropriate intervals for microbial parameters. The objective of the present study is to investigate the microbiological quality of swimming pools that had been analyzed by Water Microbiology Laboratory, Central Public Health Laboratory (CPHL) during a 7-year period.

Methods
A total of 676 swimming pool water samples were analyzed during the period 2010-2016. Out of 676 water samples, 61 were from hospitals and rehabilitation centers, 194 from hotels (including a navy's resort), 247 from municipal pools, 63 from sports pools and other private facilities, 44 from schools and 67 from children's camps and water parks. The majority of the samples (81.2%) was from Attica region, 12.9% were from Peloponnese, while the rest were from other regions of Central Greece, North Aegean and Crete. All samples were collected into sterile bottles (500 ml) with sufficient (20 mg/l) sodium thiosulfate added to each bottle for dechlorination. The samples were transferred to the laboratory at 2 °C -8 °C within 24 h from collection, using appropriate insulated coolers and were processed immediately after arrival at the laboratory. They were analyzed by the pour plate method and membrane filter technique, using 0.47mm diameter, 0.45 μm pore size filters, for the following parameters: Total Heterotrophic Plate Count (THC) at 36 °C (ISO 6222), Total Coliforms (TC) and *E. coli* (ISO 9308-1). 492 out of the total samples were additionally tested for the presence of *Pseudomonas aeruginosa* (ISO 16266). According to national regulations, swimming pool water should meet the following standards: THC < 200 cfu/ml, TC < 15 cfu/100ml and *E. coli* < 1 cfu/100ml, residual chlorine value 0,4-0,7 mg/l and pH values 7,2-7,8.

Results
Out of 676 water samples examined, 589 (87.1%) conformed to microbiological parameters set by Greek legislation. The highest percentage of conformity was observed in municipal pools (94.3%) whereas the lowest in children's camps and water parks (67.2%) (Table 1). *Pseudomonas aeruginosa* was detected in 41 samples out of the 492 examined (8.3%). Notably, 50% of the samples where *Pseudomonas aeruginosa* was detected conformed to microbiological standards set by Greek legislation. *Pseudomonas aeruginosa* was detected mainly from hospitals and rehabilitation centers (5/40 samples) (12.5%) and hotels (17/175 samples) (9,7%). Data on the residual chlorine level were

provided for 68.8% of the samples (465/676) while pH value was simultaneously recorded in 91.8% (428/465) of the samples. Interestingly, 77% of the 465 samples where the residual chlorine value was recorded didn't comply with the national regulations, with 275 water samples exceeding the upper acceptable limit (0.77 – 5.5 mg/l). The pool category where the greatest percentage of excess was recorded was the municipal pools (121/183 samples).

Conclusions

The conformity of water samples to the national standards was satisfactory for the majority of the categories. However, the higher residual chlorine levels were accompanied by better microbiological compliance indicating that the microbiological results should always be interpreted in conjunction with the residual chlorine levels; otherwise they may not reflect the actual quality of the swimming pool. *Pseudomonas aeruginosa* was detected in 8.3% of the samples tested, a relatively low prevalence rate. Given the fact that *Pseudomonas aeruginosa* has been associated with outbreaks of otitis externa, folliculitis and conjunctivitis after exposure to water from swimming pools, the need for systematic monitoring is emphasized. In conclusion, the results of the present assessment of data revealed the variability of the swimming pool water quality and emphasize the need for systematic monitoring in order to minimize possible negative health impacts.

Table 1. Number of samples compliant with the microbiological limits set by the Greek legislation in relation to pool category.

Microbiological parameter	Hospitals & Rehabilitation centers (%)	Hotels & Resorts (%)	Municipal pools (%)	Sports pools & other private facilities (%)	Schools (%)	Children's camps & water parks (%)
THC	120/125 (96,0)	110/129 (85,3)	233/247 (94,3)	59/63 (93,7)	38/44 (86,4)	47/67 (70,1)
TC	123/125 (98,4)	123/129 (95,3)	247/247 (100,0)	60/63 (95,2)	44/44 (100,0)	51/67 (76,1)
E. coli	115/125 (92,0)	128/129 (99,2)	245/247 (99,2)	63/63 (100,0)	44/44 (100,0)	63/67 (94,0)

ORAL 16

ADOPTION OF PUBLIC HEALTH MEASURES IN SWIMMING POOLS AND COMPARISON WITH MICROBIOLOGICAL PARAMETERS

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Aims

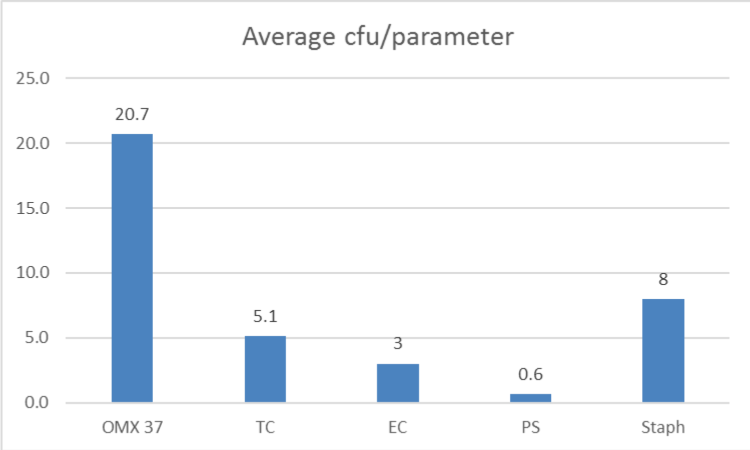
Swimming in swimming pools is an enjoyable activity contributing to good health and well-being of bathers. However, lurking several risks associated with physical agents such as accidents, drowning, fall due to slipperiness, heat, solar radiation, chemical agents such as chloramines, trihalomethanes and biological agents e.g. *Pseudomonas aeruginosa*, *Cryptosporidium Parvum, Giardia lamblia*, *Shighella* spp, *Escherichia coli* O157: H7, Norovirus, etc. Many epidemiological studies clearly show that infections caused by poor maintenance of swimming pools include a wide spectrum of clinical symptoms in the gastrointestinal system, skin, eyes, ears and respiratory system. The effects vary in type and intensity depending on the age, condition of the immune system, exposure time and dose of the microbial agent. The aim of this study was to evaluate the safety, health conditions and adoption of public health measurements, as well as the degree of compliance with applicable legislation in swimming pools, operating in the Municipality of Patras.

Materials & Methods

Pools (4) from 3 different facilities were visited and tested using standardized hygienic inspection procedures "Control Release Swimming Pool manual" (Good Operating Instructions for Swimming Pool developed in 2004) monthly from November 2016 till February 2017. Spot temperature measurements, residual chlorine, and microbiological parameters (Total coliforms, *E.coli*, *Pseudomonas aeruginosa* of pool water samples were also analyzed using standard accredited methods.

Results

Using the manual, every pool is rated for its quality and safety. A grade up to -7 is considered satisfactory, from -8 up to -13 is considered adequate and lower to -14 is considered not satisfactory. All swimming pools were considered satisfactory with rates from -4 to -2. Construction and operating problems were recorded in 75% of swimming pools, whereas problems in hygiene areas were not recorded on any case. Problems with security measures were recorded at all swimming pools. The average microbiological data for each parameter is shown in the following figure.



Conclusions

Swimming pools have been increasingly popular and possible maintenance failures might cause public health problems. All swimming pools were considered satisfactory, following the adoption to manual guidelines and checklist. The microbiological problems were considered occasional. This study confirms the importance of regular maintenance of swimming pools. There is a need to improve disinfection and cleaning procedures, with consideration given to the different uses and daily loads of each pool type. There is also a need to increase users' knowledge and awareness of the risks.

Session III

Disinfection

CHAIR: *Paola Borella, Wolfgang Uhl*

KEY SPEECH 4

STABILIZED CHLORINE – A“TICKING TIME BOMB” FOR HEALTH IN UNCONTROLLED MARKETS?”

Konrad J

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Aims

Swimming in clear lukewarm pool water in breathtaking scenery is one of the most unforgettable experiences that water lovers can bring home from their vacation. No wonder that pools are the tourism industry's most powerful booking tool. Their international B2B travel shows can be easily mistaken at first glance as swimming pool shows. When it comes to exotic and hot destinations: the tropics, an investigative professional for pools can't help asking the hotel GM or tour operator the question: “Do you really know, what are you selling here?” His findings are based on investigations: whether water disinfection and quality control practices in tropical Asia are suitable to prevent health risks to international tourism. In Western countries, hygienic safety and water quality has absolute priority. Civilization is expressed here by sophisticated guidelines, responsible management practices, efficient quality control and above all, education. In contrast, almost all of the popular tourist destinations in the tropics are emerging or even developing countries. Every year new destinations are becoming more and more accessible to tourists. These countries most likely harbor a swimming pool for the first time in their history. Moreover people and their guests are exposed in the tropics to an environment with the highest infectious pressure on earth. In some areas such as in Africa, tourists can be even exposed to endemic waterborne pathogens or strains when the supply water to the pool and the pool water itself is not properly treated and disinfected. The question must be asked, who here understands and cares pool quality? Their guests have no choice but to hope that the pool operators are well trained. Seriously? There must be some reasons why water disinfection with "chlorine" is understood by pool operators in the tropics as a very simple process. Trichloroisocyanuric acid (TCCA) commonly referred to as "stabilized", "organic" or "90% chlorine" is dosed as granulate simply with a bucket directly into the pool. As the name indicates, it contains Cyanuric Acid (CYA), which acts as a “stabilizer” for chlorine so it can longer withstand the ultraviolet rays of the sun from degradation. As it doesn’t degrade in water and steadily builds up with continued use the increasing concentration of CYA will reduce both the disinfection power and oxidation potential (ORP) of free chlorine. At 100 ppm CYA only 12 % of the measured free chlorine concentration would be available to disinfect. Such an over-stabilization of chlorine can develop at even higher CYA concentrations to a complete chlorine lock. It has been investigated to what extend over-stabilization is a problem in tropical pools.

Methods

1. Since 1994 approximately 500 hotel swimming pools, 150 condominium and public swimming pools and 30 water parks have been inspected. Water tests for chemical parameters were carried out and the chief engineers of the hotels consulted. They provided in return insights into the practiced water treatment process.

2. 2008 - 2011: Publication of the English language pool & spa magazine POOLASIA and the Thai / English magazine TARA in Thailand. The presentation of pool properties and "Best of ..." attracted the attention of the hotel managers and made this survey possible.
3. Organization of the POOLASIA EXPO 2011 in Phuket, Thailand, tropical Asia's first international pool & spa trade show with 2700 sq. m. exhibition area and 68 participants from 20 countries. Thanks to this event the awareness conference "Tourism & Healthy Water" could be organized, as well the 1st Certified Pool Professionals Course with participants from e.g. Sumatra. The invited tourism industry has shown how important the topic is to them.

Results

In over 98% of the 650 examined swimming pools in tropical Asia the "orthotolidine (OTO)" method was used to determine the "chlorine" content. Not a single hotel manager was aware that the inexpensive OTO pool tests can't tell if and how good the pool is disinfected, as this method is not suitable for the selective determination of free chlorine. Not a single hotel manager who grew up and was trained in the West knew that different methods are on the market, that the OTO method is banned and only the DPD 1 method is permitted in his home country to determine free chlorine. The concentration of free chlorine was mostly 10 – 30% or even close to nil of the results measured with the OTO method. In most countries in tropical Asia cyanuric acid is almost omnipresent in all kind of pools. From 120 inspected 4 and 5-star or luxury hotels and resorts only two owned a measurement device for CYA. 60% have had CYA concentrations in the range of 100 – 200 ppm. 10% above 200 up to 400 ppm. The highest cyanuric acid concentration of 1200 ppm was measured in the year 2000 in all three pools of a large condominiums complex for expats. Here, a swimming pool patron suffered from severe Giardiasis which required hospitalization for 2 weeks. He reported that he met other Giardiasis affected pool-loving expats in the same hospital who resided in other apartment complexes nearby. 16 years later during the raining season in 2016 these swimming pools were tested again with cyanuric levels of average 400 mg/l and a pH of 3.5. 95% of 160 tested hotel pools have had ORP levels of below 600 mV and 30% below 450 mV. 20 % have had pH values below 6.8, out of the measurement range of the test kits in use.

Conclusions

Most swimming pools in tropical Asia could be an infection risk by taking into account that free chlorine is almost always determined with the orthotolidine method (OTO). To make things worse, the extremely popular TCCA is used excessively and almost always without control of the CYA concentration. Consequently at least 50 % of all inspected 650 pools were over-stabilized and almost all of them have had ORP values below 600 mV due to low concentrations of free available chlorine. Training of the local operators has to be demanded. No Western country would allow their citizens to swim in pool water which provides such low disinfection efficiency. However, their own tour operators are unknowingly doing that, uncontrolled, far away in tropics. To compound the problem, why should a hotel manager of a tropical resort worry too much about water quality if a German, Swiss or Austrian tour group is checking in from countries with the world's highest pool water quality standards? Every time he feels how much they appreciate what a good job he is doing. The low acid values seem to be responsible for the pristine clear water. It's the cause for the heavy damage of the pool grouting and for dental erosion, as investigated and published firstly by Thai researchers. Thailand was the first and only country in tropical Asia which in 2007 incorporated the limit value of 70 mg/l into their guidelines. There is a great potential for responsible tour operators, destination and hotel managers, educated in the West, to promote quality as "Ambassadors for Healthy Water" in the tropics.

ORAL 17

AFM FILTRATION AND WATER QUALITY OF AN INDOOR PUBLIC POOL IN THE NETHERLANDS AND AN OUTDOOR POOL IN SPAIN

Dryden H

DrydenAqua, Scotland

Media bed filters are the heart of most pool water treatment systems, yet it is often the most neglected and understood. The clarity of the water, the consumption of chemicals, production of disinfection by-products as well as the safety of the bathers are all connected and depend upon the stability and performance of the filtration system. A public pool in the Netherlands Bad Hesselingen was monitored by C-Mark and the performance of the filtration system was quantified.

Pools exposed to strong sunlight, suffer from photo-oxidation of hypochlorous, Cyanuric acid may be used to conserve the chlorine, but a better option is to protect the chlorine and boost its performance with ACO photo-catalysts. Terra Natura, a large outdoor pool in Spain is used as an example to demonstrate chemical savings.

ORAL 18

AN INNOVATIVE APPLICATION OF OZONE-UV TREATMENT FOR SWIMMING POOL WATER DISINFECTION

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Aims

Swimming pool water disinfection is a crucial treatment step for reducing the risk of infections for bathers. The most commonly applied disinfection method in pools is chlorination, which has strong disinfecting power and provides residual chlorine as an added measure of protection. However, chlorination has two major drawbacks: Firstly, some pathogens (e.g. *Cryptosporidium* oocysts) have been proven to be resistant to chlorine. And secondly, chlorine can react with organic and inorganic constituents in water to form disinfection by-products (DBPs) which can have adverse effects on human health. Consequently, alternative disinfection technologies seem to be the way forward.
Ozone and UV have been proven to be effective for inactivation of chlorine resistant pathogens (WHO, 2006), however, neither ozone nor UV are able to provide residual disinfection, which is still a worldwide requirement for disinfection of swimming pools. Hence the goal of this research was to assess the disinfection efficiency of ozone-UV treatment in combination with low doses of chlorine, with the aim of reducing the formation of chlorinated DBPs (e.g. trihalomethanes, haloacetic acids), while providing a barrier for chlorine resistant microorganisms.

Methods

The model water used in all experiments was sterilized tap water spiked with body fluid analogue (BFA) according to recipe described by Judd *et al.* (2003) to simulate urine, sweat and other anthropogenic contaminants released by bathers. The final concentration of BFA in the model water was 1 mg-C/L. The pH of the model water was adjusted to 7.3 in all experiments. The experiments were carried out at room temperature (22±1 °C). The model water was spiked with *B. subtilis* spores to achieve a final concentration of 10^5-10^6 CFU/mL. The concentration of *B. subtilis* spores was assayed using spread plate method with Columbia blood agar base. The plates were incubated at 37±1 °C for 24±2 hours and the colonies formed were counted using a colony counter. The ozone-UV disinfection was conducted by using ozone, which was produced by an ozone generator and a vertical flow-through UV reactor equipped with a 180 W low pressure UV lamp. For the disinfection experiments, an ozone solution (3.2±0.2 mg O_3/L) was prepared by bubbling ozone gas through demineralized water. The concentration of dissolved ozone was monitored by an ozone sensor. The ozone solution was continuously introduced into model water with a 1:9 ratio to reach the concentration of dissolved ozone in model water of 0.1 mg/L before entering the UV chamber. Water samples were collected after passing through the UV reactor. In the disinfection experiments applying ozone-UV followed by chlorination, after ozone-UV treatment the water was collected in a brown glass bottle. Next, chlorine stock solution (25 g Cl_2/L) was added to the model water to have an initial concentration of 8 mg Cl_2/L. After a certain contact time, samples were collected and immediately sodium thiosulfate was added to quench the free residual chlorine. Samples after ozone-UV step, as well as after chlorine addition were analysed for *B. subtilis* viability. In separate identical experiments, using model water without spiking of *B. subtilis* spores, water samples were analysed for trihalomethanes (THMs), haloacetic acids (HAAs) and bromate. The single step disinfection experiments of chlorination, UV and ozone-UV were carried out before applying the combination of ozone-UV and chlorine.

Results

The inactivation kinetics showed that the inactivation rate constant of ozone-UV was 0.10 cm^2/mJ while in only UV treatment was 0.07 cm^2/mJ. Ozone-UV treatment yielded a 2-log reduction of *B. subtilis* spores at UV fluence of 20.2 mJ/cm^2 whereas 2-log reduction was achieved at CT value of 271 mg.min/L during chlorination. The application of ozone-UV followed by chlorination improved the inactivation of *B. subtilis* spores by 13%. During the single step chlorination, the measured concentration of total THMs and HAAs were 23.2±3.5 µg/L and 17.4±3.5 µg/L, respectively. In the model water treated by ozone-UV followed by chlorination, the total THMs and HAAs were measured 25.6±3.8 µg/L and 17.5±3.5 µg/L, respectively, indicating that the THMs and HAAs were formed due to chlorination and were already present in the model water at a very low concentration. Moreover, although there was bromide present in the model water, no bromate was found in the water after ozone-UV treatment.

Conclusions

B. subtilis spores inactivation was enhanced by applying ozone prior to UV as compared to UV only. Ozone-UV treatment showed to be more efficient in inactivation of *B. subtilis* spores compared to chlorination. Moreover, there was no THMs and HAAs were formed by ozone-UV treatment. The application of ozone-UV may be instrumental for providing a sustainable disinfection, particularly for chlorine resistant pathogens, while minimizing DBPs formation by lowering the chlorine dose but still adequate to provide residual disinfection in swimming pools.

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ORAL 19

MICROBIAL QUALITY OF SWIMMING POOL WATER WITH TREATMENT WITHOUT DISINFECTION, WITH ULTRAFILTRATION, WITH UV-BASED TREATMENT AND WITH CHLORINATION

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Aims
Swimming pools are traditionally disinfected with a residual disinfectant such as sodium hypochlorite. Nowadays, swimming water without a residual disinfectant is increasingly popular, as can be seen by the growing number of (natural) swimming ponds (Weilandt 2015), but health risks for bathers do raise concerns for these type of pools, so some form of disinfection is needed (Giampaoli et al. 2014). The combination of ultra-filtration and UV-disinfection for pool water treatment, without a residual disinfectant might be an interesting alternative. The Dutch Innovative Pool project (DIPool) was initiated to explore this new treatment concept, to study its applicability for swimming pools and to verify first system design specifications. The goals of this study were to compare the microbial water quality during treatment without disinfection, treatment with ultra-filtration, treatment with UV-disinfection, treatment with chlorination, and the influence of single treatment steps.

Methods
All treatment concepts were studied in a pilot plant equipped with a pool basin and simulated bathing load, containing only chemical components. Adenosine triphosphate (ATP) and intact cell count measurements were used to monitor the microbial water quality before and after each treatment step at regular intervals in several experiments during 23 days of operation. High pollutant/nutrient conditions without recirculation were used to study the effect of single treatment steps, and recirculation conditions were used to study the effect of accumulation of pollutants/nutrients. A chlorinated pilot plant was used as reference for the alternative disinfection. The influence of a biological activated carbon filtration during chlorinated conditions was also investigated. Both pilot plants were operated at 1 m^3/h, with a turnover time of 30 minutes during the recirculation conditions.

Results
The results showed that the microbial quality of pool water with UV-disinfection was similar to that of chlorinated pool water, while pool water treatment without disinfection resulted in a higher microbial number. After 23 days, most of the results during chlorination and UV-disinfection experiments with recirculation were within 10^3-10^5 intact cells/mL and 0.2-13 ng intracellular ATP /L which is similar to both bottled and tap water. Treatment steps with the highest reduction in microbial quality were ultrafiltration (UF) in the treatment setup with UV-disinfection and chlorination in the treatment setup with chlorination. The largest increase in microbial quality was observed during residence in the pool basin, which was obvious, and during biological activated carbon filtration.

Most important conclusions were that i) the microbial water quality of pool water with a UV-based treatment can be similar to that of pool water with chlorination ii) UF plays an important role in maintaining a low number of micro-organisms during UV-based treatment and iii) P-limitation is an additional method to limit microbial growth in swimming pool water.

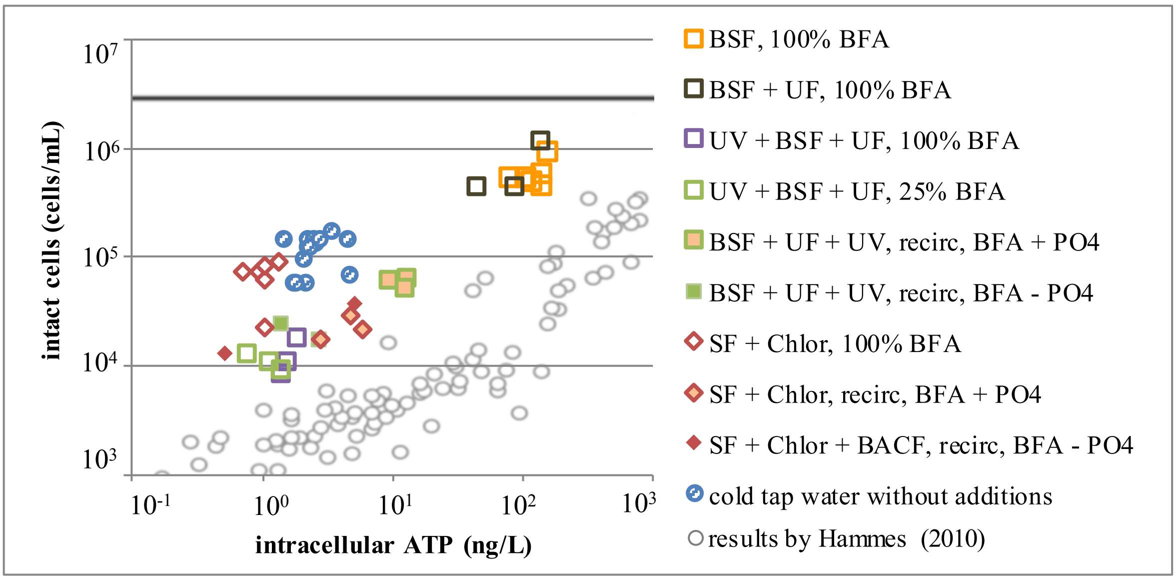

Figure 1: Microbiological water quality, quantified as concentration intact cells and cATP, during all experiments, with and without recirculation, both with different treatment steps: sand filtration (SF) + chlorination (Chlor), SF + Chlor + biological activated carbon filtration (BACF), biological sand filtration (BSF), BSF + ultra-filtration (UF), UV-treatment (UV) + BSF + UF and with different BFA compositions.

Conclusions

This study showed that pool water treatment based on UV-disinfection consisting of biological filtration, UF and UV-treatment combined with a 30-minute turnover time, is able to maintain the microbiological quality similar to chlorinated pool water during a simulated high occupancy level of a pool without the use of a residual disinfectant.

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ORAL 20

INVESTIGATING CHLORINE DIOXIDE AS AN ALTERNATIVE FOR INACTIVATING *CRYPTOSPORIDIUM* IN AQUATIC VENUES THAT USE STABILIZED CHLORINE

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Aims

Cryptosporidium is an extremely chlorine-resistant pathogen. To effectively inactivate *Cryptosporidium* (i.e., achieve 3-$\log_{10}$ [99.9%] inactivation), the U.S. Centers for Disease Control and Prevention recommends that aquatic venue (e.g., pools) operators clear the venue of bathers and achieve free chlorine concentrations of 20 mg/L for 12.75 hours—a process that can considerably disrupt normal operations. Inactivation times might need to be at least 8 times longer when the chlorine stabilizer, cyanuric acid (as a stand-alone additive or in the form of dichloro-s-triazinetrione [“dichlor”] or trichloro-s-triazinetrione [“trichlor”]), is present in the water. These longer contact times are not feasible for most aquatics venues, resulting in a situation in which the only option is to at least partially drain the water, add water without cyanuric acid (CYA), hyperchlorinate, and then return chlorine to the appropriate level to protect bather health. Recent laboratory research indicates that chlorine dioxide (ClO_2) is highly effective against *Cryptosporidium parvum* (achieving 3-$\log_{10}$ inactivation in approximately 2 hours at a dose of 5 mg/L), and that the presence of free chlorine might shorten inactivation times. However, it is unclear what effect CYA has on ClO_2 inactivation rates. The aim of this study was to determine if ClO_2 can serve as an effective and feasible alternative to hyperchlorination of aquatic venues that utilize stabilized chlorine. The technical objective was to determine the time required to achieve a 3-$\log_{10}$ inactivation of *C. parvum* oocysts at 5 mg/L ClO_2; 2 mg/L free chlorine; and 50, 100, or 150 mg/L CYA.

Methods

Laboratory studies were conducted under ideal conditions (oxidant-demand-free water [ODF] at 2 mg/L free chlorine, pH 7.5, 25 °C) with CYA added to achieve target concentrations of 50, 100, or 150 mg/L. A stock solution of concentrated ClO_2 was prepared and added to triplicate experimental flasks to achieve a final ClO_2 concentration of 5 mg/L. A fourth flask was used to measure ClO_2 decay over experimental time periods; it was equal in volume to experimental flasks and seeded with an equal quantity of *C. parvum* oocysts, but sodium hypochlorite was not added to prevent measurement interferences. Control experiments included flasks containing: 1) 2 mg/L free chlorine and 5 mg/L ClO_2; 2) 20 mg/L free chlorine; and 3) ODF water to measure natural *C. parvum* decay. Flasks were continuously stirred and samples were removed at select time points for *C. parvum* infectivity testing. Samples were quenched using sodium thiosulfate, concentrated by centrifugation, inoculated onto MDCK mammalian cells and incubated for 48–60 hours at 37 °C under 5% CO_2. A *Cryptosporidium*-specific monoclonal antibody was used to fluorescently label *C. parvum* living stages before microscopic counting. Images of fluorescing living stages were collected using a digital camera attached to a Zeiss Axiovert microscope at 100X magnification. Zeiss AxioVision and ImageJ software were used to quantify the number of living stages (survivors) associated with each inactivation experiment sample and back-calculation provided an estimate of the log inactivation of oocysts over contact time.

Results

A total of six individual experimental flasks were tested for each CYA concentration. At an average of 53 mg/L CYA and 2.4 mg/L free chlorine, dosing to 5 mg/L ClO_2 resulted in a 3-$\log_{10}$ inactivation of oocysts in <3 hours. At an average of 119 mg/L CYA and 2.3 mg/L free chlorine, a 3-$\log_{10}$ reduction was achieved in 3 hours. At 186 mg/L CYA and 2.1 mg/L free chlorine, a 2.4-$\log_{10}$ reduction was achieved within 5 hours. All control assays indicated that oocysts did not exhibit differences in inactivation or die-off rates that were substantially different than those reported in previously published research reports.

Conclusions

These data indicate that ClO_2 might serve as an effective alternative to hyperchlorination in aquatic venues that utilize stabilized chlorine, even at CYA concentrations that exceed the maximum of 90 mg/L recommended by the U.S. Model Aquatic Health Code. Our previous work indicates that at CYA concentrations of 50–100 mg/L, utilizing hyperchlorination to achieve 3-$\log_{10}$ inactivation of *C. parvum* requires $\geq$102 hours at 20 mg/L free chlorine concentration. Alternatively, 3-$\log_{10}$ *C. parvum* inactivation in the presence of 50–100 mg/L CYA can be achieved within 3 hours at 5 mg/L ClO_2. Next steps for this research project include calculation of contact time values that incorporate ClO_2 for each CYA concentration and statistical comparison of data from this study with those of previous studies. Use of ClO_2 as an alternative to hyperchlorination, might allow aquatic venues to avoid or reduce the time for disruptive, potentially costly, closures. However, more research is needed before ClO_2-based *C. parvum* remediation procedures that incorporate occupational and swimmer health and safety considerations are implemented.

ORAL 21

QUANTITATIVE MICROBIAL RISK ASSESSMENT FOR AN INDOOR SWIMMING POOL WITH CHLORINATION COMPARED TO A UV-BASED TREATMENT

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Aims

Most swimming pools use residual disinfectants like chlorine for disinfection. The use of chlorine has several drawbacks: some waterborne-pathogens are chlorine resistant and disinfection by-products (DBPs) may be formed which are associated with various health risks. Therefore, an alternative treatment was developed which consists of biological sand filtration, ultra-filtration and UV-disinfection. The goal of this study was to compare the microbial risks for bathers in a UV-disinfected pool compared to a chlorinated pool with the use of a quantitative microbial risk assessment.

Methods

In this microbial risk assessment, the microbial release was calculated from multiple factors such as pool content, number of simultaneous swimmers, duration and frequency of swimming, ingestion of pool water, the hygienic behaviour of swimmers and the actual release of microbial cells per swimmer. The concentration of faecal bacteria was calculated from shedding experiments and known pathogen concentrations in faeces. The Dutch illness probability (283/1000) was used to calculate the number of infected bathers, which were all assumed to sheds 10^8 faecal pathogens per g faeces. The used reference pathogens were *Campylobacter jejuni*, *E. coli* O157:H7 and *Salmonella enterica*. The removal of pathogens by treatment with UV-disinfection was set to 5-log units, every 4 hours, while during chlorination these 5-log units are known to be achieved in 30 seconds. The dose-response relationship for *E. coli* and *S. enterica* was simulated with a beta-Poisson distribution and for *C. jejuni* a hypergeometric function was used. The yearly risk of infection was calculated separately for each of the bacterial pathogens and a normal range sensitivity analysis was done.

Results

The average bacterial cell concentration during opening hours in a UV-based swimming pool were the highest for *C. jejuni* (3.1×10^{-3} cells L^{-1}) > *S. enterica* (9.5×10^{-4} cells L^{-1}) > *E. coli* (7.2×10^{-4} cells L^{-1}). These calculated pathogen concentrations were about 180 times higher than calculated pathogen concentrations in a chlorinated swimming pool in which the averaged concentration was 4.0×10^{-6} cells L^{-1} for pathogenic *E. coli* cells. Based on the average pathogen concentration during opening hours, the yearly risk of infection was calculated to be 9.8×10^{-8} for the chlorinated swimming pool and 1.8×10^{-5} for the UV-based swimming pool treatment. The yearly risks of infection of a UV-based treated swimming pool were the highest for *C. jejuni* (1.7×10^{-3}) > *E. coli* (1.8×10^{-5}) > *S. enterica*

(3.5×10^{-7}). The simulated yearly risk of infection was found to be most sensitive for the number of bathers releasing pathogens.

Conclusions

The yearly risks of infection of *E. coli* and *S. enterica* in a UV-based treated swimming pool were lower than the drinking water guidelines (10^{-4}), but for *C. jejuni* it was higher. For a more complete picture of the health risks, the effects of disinfection by-products should also be taken into account in future risk assessments, as is the effect of other pathogens like *Pseudomonas*, *Cryptosporidium* and *Giardia*. UV-based treatment might be a good alternative for chlorination for some specific types of swimming pools.

ORAL 22

ELUCIDATING THE IDENTITY AND MUTAGENICITY OF DISINFECTION BYPRODUCTS ORIGINATING FROM SUNSCREENS IN CHLORINATED SEAWATER SWIMMING POOLS

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Aims

Sunscreens are widely used nowadays due to concerns about adverse health effects associated with exposure to solar ultraviolet (UV) radiation. In swimming pools, ingredients of sunscreens worn by swimmers are released into water upon immersion. As organic compounds, these ingredients can react with chlorine leading to the formation of disinfection byproducts (DBPs). The potential of sunscreen ingredients to act as precursors for the formation of DBPs in chlorinated swimming pools and the mutagenicity of the formed byproducts have received little consideration. The scarcity of data is especially remarkable for seawater-filled pools. This study aims at identifying DBPs originating from sunscreen active ingredients (UV filters) in seawater swimming pools treated with chlorine. The study also aims at assessing the mutagenicity of the formed byproducts in this type of pools.

Methods

Five organic UV filters commonly found in sunscreens were studied. The UV filters were namely, benzophenone-3, benzophenone-8, avobenzone, ethylhexyl methoxy cinnamate and octocrylene. The reactivity of the UV filters was investigated by chlorinating seawater spiked with each UV filter. Reactions were stopped at different time points to track the kinetics of the reactions taking place and to monitor the transformation byproducts appearing during reactions. Extraction of potentially formed DBPs was performed using liquid-liquid extraction (LLE) with methyl *tert*-butyl ether (MTBE). Formed DBPs were analyzed and identified using gas chromatography coupled to electron-capture detector (GC-ECD) and ultrahigh performance liquid chromatography coupled to high-resolution mass spectrometry (UPLC-MS). For the mutagenicity assessment of the final solutions, MTBE extracts were dry concentrated and solvent exchanged with dimethyl sulfoxide (DMSO). DMSO Extracts were then tested with the Ames test using Salmonella strains TA98 and TA100.

Results and Conclusions

Among the studied UV filters, four compounds were found to react with chlorine in seawater leading to the formation of bromoform as a final byproduct. Bromal hydrate was also formed from the chlorination of BP-3 and BP-8 in seawater. The highest bromoform formation yields were detected for the benzophenone UV filters BP-3 and BP-8. Several brominated transformation byproducts resulting from electrophilic aromatic substitution reactions of the UV filters were identified using UPLC-MS/MS. The transformation pathways of the UV filters were proposed based on the identified byproducts. The analysis of mutagenicity of the transformation byproducts (except the volatile byproducts including bromoform and bromal hydrate which were eliminated during solvent exchange) showed that BP-8 byproducts induced significant mutagenicity in Salmonella TA 98. These findings show that UV filters of sunscreens contributed to the formation of DBPs such as bromoform or bromal hydrate in swimming pools filled with seawater and treated with chlorine. In addition to bromal hydrate and bromoform that are known to be genotoxic, other brominated transformation products of some UV filters were significantly mutagenic.

ORAL 23

THE EFFECTS OF ULTRAVIOLET ON BACTERIAL VIABILITY IN A LABORATORY SWIMMING POOL MODEL

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Aims

Swimming pools are an ideal place for exercise, amusement and relaxation. But they are also an ideal place for bacteria to grow, which may cause illness to humans. Until now, the only effective way, to disinfect the water, was the addition of chemicals (mainly chlorine), but with major drawbacks (production of trihalomethanes) for humans and the environment. An alternative, promising and environmentally friendly disinfection method is the use of UV light. Using UV for disinfection lowers the chemical cost and usage, lowers disinfection by-products and provide for less intensive maintenance. The aim of this study was to evaluate the effects of UV exposure (UV-C) on various microorganisms by using a laboratory model of a swimming pool which simulates the conditions of an actual swimming pool.

Materials & methods

The model pool simulated an actual swimming pool of Olympic dimensions and was constructed from Plexiglas material, in scale 1:250. The tank dimensions where 33x25x2 cm and the maximum capacity was 45 liters. A peristaltic pump circulated the water at a flow rate of 18L/h. A 10 watt UV lamp (set at 254 nanometers wavelength) with maximum purification capacity of 500 liters per hour was used. A thermostat was placed at the center of the model pool to keep the temperature at 25 °C. Throughout the course of the experiments the pH ranges from 7.2 to 8.2. The bacterial strains used were: Escherichia coli NCTC 9001, Staphylococcus aureus NCTC 6571, Pseudomonas aeruginosa NCTC 10662 and Enterococcus faecalis NCTC 775. These bacteria are mainly used as indicators in swimming pools.

The water was circulated for two and a half hours with the UV light turned off, to allow the system to settle in the pool. At that time a sample was collected, and then the UV light was turned on. Samples where collected at varying intervals up to two days. All water samples were analyzed by membrane filtration technique. Standard techniques used always during sampling. The microbiological treatment performed according to ISO 16266:2006 for Pseudomonas aeruginosa, ISO 7899-02:2000 for Enterococcus faecalis and ISO 9308-01:2000 for *Escherichia coli.*

Table 1: Sample collection of 1^{st} and 2^{nd} day

DAY	NUMBER OF SAMPLING	RECIRCULATION/UV	SAMPLING VOLUME/ADDITION OF STERILE TAP WATER
1	1^{st}	AFTER 2.5h/0 min	200 ml
1	2^{nd}	Yes/15 min	200 ml
1	3^{rd}	Yes/30 min	200 ml
1	4^{th}	Yes/60 min	200 ml
1	5^{th}	Yes/120 min	200 ml
1	6^{th}	Yes/180 min	200 ml
2	7^{th}	No/0 min	200 ml
2	8^{th}	Yes/150 min	200 ml
2	9^{th}	Yes/300 min	200 ml

Results

The reduction of all microorganisms was effective up to 1.61 logs after 8 hours of continuing UV disinfection. On the first day, all microorganisms showed a significant log reduction except from P. aeruginosa. All the microorganisms exhibited lowest log reduction on the first day, compared to the second where the reduction continued with a greater rate. S.aureus showed the greatest log reduction in comparison with all the other microorganisms. The efficiency of UV treated pool model seemed to be dependent on the following factors: (1) flow rate, (2) intensity of UV lamp and (3) hours of UV treatment per day.

Conclusions

Data obtained during this study, suggested that UV disinfection can effectively reduce or eliminate bacteria existing in a closed circulating pool water system, thus reducing problems concerning public health by creating a healthier environment for the swimmers.

Session IV

Hydrotherapy Pools

CHAIR: *Aurelio Crudeli*, *Vasiliki Karaouli*

KEE SPEECH 5

HOT SPRING WATERS IN POOL: THE PERSONALIZATION OF TREATMENT FROM MFDNA FINGERPRINTING TO NANOTECHNOLOGIES

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Aims
Beneficial properties of thermal waters (TWs) are related to their specific natural composition, characterized by chemical, physical and biological features. TW are very heterogeneous and each unique pattern requires appropriate management to avoid adulterations, as reported by guidelines and regulations[1,2]. However, exploitation of TWs qualities imposes handling and hygiene. How to join disinfection procedures with the respect of natural properties? This question is relevant for all TWs applications and becomes very challenging when therapeutic or recreational activities are performed in pools. Moreover, TW may carry a natural microbial flora that is mainly unknown and unculturable. The TW microbiota may represent a biological signature? How chemical composition or treatments can interfere with this biodiversity? In order to characterize the bio-fingerprint of hot spring waters a Next Generation Sequencing (NGS) approach was applied and mfDNA patterns described within a rDNA evolutive frame. Several treatment strategies were evaluated to the aim of protecting the TW natural composition. Current regulations do not allow disinfectants in medicinal waters and alternative methods are needed. Otherwise, traditional Chlorine addition, would change the natural TW structure by induction of insoluble compounds, disinfection by products (DBP) and chemical risks, as already investigated for swimming pools on different exposed populations[3]. Ozone or UV are effective, but have no residual activity. A commonly used solution is based on dilution of pollutants by frequent replacing of TW, but this approach is unsustainable for larger structures and/or when supplied by small aquifers. Several alternatives have been proposed e.g. ions, electrolysis, but are still unsatisfactory. Classical filtration and promising phytodepuration strategies require further investigations. Research also focused on regenerating TWs natural properties and implementing native antimicrobial potentials associated to salt composition, pH or H_2S[4]. Combining different processes showed that an integrated approach may provide synergistic effects. During last decades, nanotechnology photocatalytic processes opened promising perspectives that were tested using a semiconductor (e.g. TiO_2) to produce reactive oxygen species (ROS) and inactivate microorganisms by light exposure. As in personalized medicine, an integrated approach based on individualization of treatments was evaluated and proposed for TW guidelines.

Methods
Review of scientific literature, guidelines and regulations. Sampling and characterization of TW from different Italian SPA. Isolation of mfDNA and NGS analysis. Evaluation of candidate technologies for treating TW by in field tests and a lab assay also using a scale-pool prototype. Testing antimicrobial activity of photocatalytic materials on several kinds of TW and implementation under different exposure conditions.

Results

Hot spring waters have a specific genetic fingerprint related to the heterogeneous composition of the bacterial microflora (Figure). These species are not pathogens, may play a role in therapeutical applications or wellness and represent a natural component within that ecosystem. Characterization of the bacteria microflora and chemical-physical properties showed individual patterns specific for each SPA spring. Comparison of different TW fingerprints allowed to draft their distribution on different areas of Italy and define possible maps. Isolation of TW specific microbial strains allowed their genomic characterization opening new perspectives for wellness, cosmetics and biotechnology applications[5]. Evaluation of different technologies for water treatment indicated solutions that appeared more respectful of the TW natural composition when joined with adequate recirculation and replenishment. Several innovative filtration membranes and systems were tested in small-scale experiments confirming the potential effectiveness on thermal waters under different conditions. Nanotechnologies based on implementation of photocatalytic activity revealed potentially effective (Table) and promising also under different light wavelength or material conformations. A "personalized" approach is proposed based on water composition, mfDNA fingerprint, and individualized laboratory tests for simulating TW response to contaminations and the TW compliance with different water treatments.

Conclusion

Although the tradition of Thermae/SPA is ancient and successful, nowadays modern hygiene requirements and technological advancements strongly suggest considering an update in TWs treatments. The complexity of this public health question imposes a wider approach, focused on assessment of all available technologies and implementation of integrated approaches that can be respectful of TW composition, identity and quality. A personalized approach to treatment can be based on characterization of TW chemical, physical and biological parameters. Further research and experience can open up perspectives for new guidelines.

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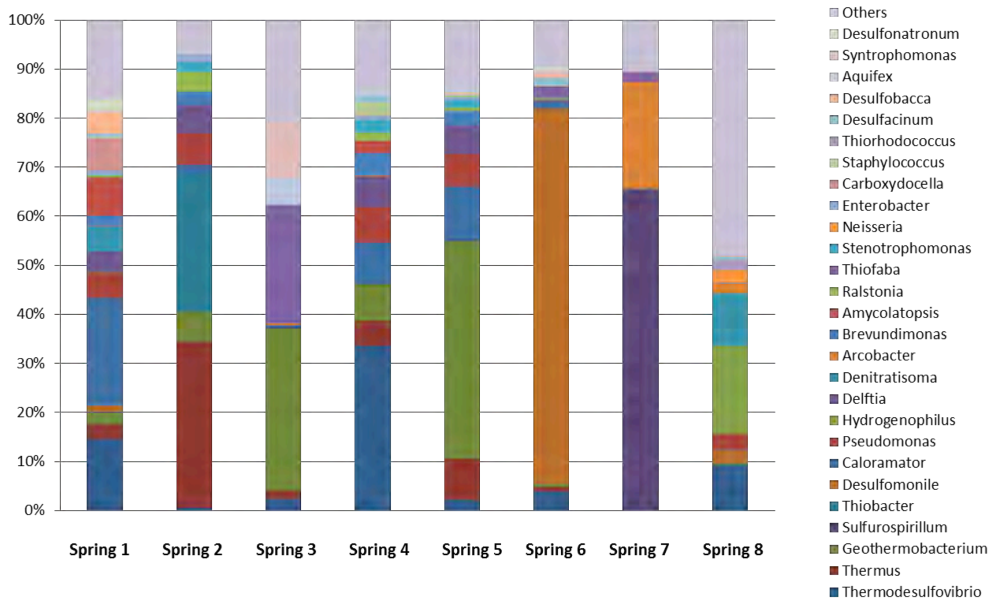

Figure. SPA water typing by NGS biofingerprint. Representative output at genus level: biodiversity and relative distribution of bacterial 16S rRNA gene sequences in several hot spring waters (cut-off 2.5%).

Table. Photocatalytic effect. Bacterial growth after light exposure. Mix 1 and 2: different formulations of semiconductor (TiO_2) contaminated with microorganism (*E. coli* ATCC 35218).

	Mix 1		**Mix2**	
Sampling time	**Dark (% bacteria load)**	**Lux (% bacteria load)**	**Dark (% bacteria load)**	**Lux (% bacteria load)**
0 h	100	100	100	100
<1 h	81,8	29,1	72,1	13,1
1-5 h	61,0	7,1	65,4	0,0

ORAL 24

MICROBIOLOGICAL QUALITY OF THERMAL WATERS IN GREECE: ASSESSMENT OF 5 YEARS DATA FROM THE CENTRAL PUBLIC HEALTH LABORATORY

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Aims
Natural mineral waters or spas are part of the country's national wealth, scattered throughout the country. Apart from cold mineral springs, there are also hot spring sources which are used for therapeutic treatment. The aim of the present study is to assess the microbiological quality of thermal waters subjected for analysis to the Water Microbiology Laboratory, Central Public Health Laboratory (CPHL) during a 5-year period (2012-2016).

Methods
The Water Microbiology Laboratory, CPHL accepts samples from National Public Health Authorities which perform supervisory control. Within the above time period, 182 thermal water samples from the administrative regions of Central Greece (n=61), West Greece (n=24), Peloponnese (n=28) and North Aegean (n=69) were sent to our laboratory for microbiological examination, according to Greek legislation. Water samples were from hydrotherapy centres (pools and thermal springs), were not subjected to any disinfection procedure and were all used for hydrotherapy - balneotherapy treatments. All samples were collected into sterile bottles (500 ml) with sufficient (20 mg/l) sodium thiosulfate added to each bottle for dechlorination. The samples were transferred to the laboratory at 2 °C -8 °C within 24 h from collection, using appropriate insulated coolers and were processed immediately after arrival at the laboratory. They were analyzed by the pour plate method and membrane filter technique, using 0.47mm diameter, 0.45 μm pore size filters, for the following parameters: total heterotrophic plate count (HPC) at 36±2 ^{0}C (ISO 6222), total coliforms (TC) and *E. coli* (ISO 9308-1) and *Pseudomonas aeruginosa* (ISO 16266). The microbiological quality of the samples was evaluated according to standards established by national regulation (HPC <200 cfu/ml, TC <15 cfu/100ml, *E. coli* <1 cfu/100ml, *Pseudomonas aeruginosa* <10 cfu/100ml for natural spas).

Results
The samples were not distributed evenly during the study period due to the nature of the monitoring. Analysis revealed that 66/182 of the samples (36.3%) did not comply with the national regulations. More specifically, the most frequent violation (59%) concerned *Pseudomonas aeruginosa* (range 13 - 710 cfu/100ml) followed by violations in *E. coli* (54.5%, range 4 - >$1.0x10^3$ cfu/100ml), TC (53%, range 18 - $1.0x10^5$ cfu/100ml) and HPC (36.4%, range 210 - >$3.0x10^3$ cfu/ml). Additionally, 44% of the non-compliant samples violated simultaneously two microbial parameters. The best compliance rate is recorded in 2014, year that the Water Microbiology Laboratory, CPHL analyzed the majority

of the total number of samples (n=92) (Table 1). In 21.4% of the total samples *Ps. aeruginosa* exceeded the upper legal limit, with values ranging from 13 cfu/100ml to 710 cfu/100ml. All of the *Ps. aeruginosa*-positive samples did not comply with the microbiological limits set by national regulations, with the presence of *E. coli* being the most prevalent violation.

Conclusions
There is a high percentage of samples by spa environments not complying with the national regulations, indicating an urgent need for improving hygienic conditions. The higher frequency of testing in the Water Microbiology Laboratory, CPHL is related with better compliance of samples' sources. Because of the variation in the results by geographical area there is a need for a homogenous approach based on higher frequency of testing for further promoting health safety of spa environments in Greece.

Table 1: Number of thermal water samples non-compliant with the national regulations per year and origin (% non-compliant in parenthesis).

	2012	**2013**	**2014**	**2015**	**2016**	**TOTAL**
Central Greece, Eoboea		3/11 (27.3%)	8/31 (25.8%)	6/19 (31.6%)		17/61 (27.9%)
West Greece, Aetolia-Acarnania	1/1 (100.0%)	5/7 (71,4%)	5/11 (45,5%)			11/19 (57.9%)
West Greece, Achaea	1/1 (100.0%)	1/1 (100.0%)				2/2 (100.0%)
West Greece, Ilia					3/3 (100.0%)	3/3 (100.0%)
Peloponnese, Corinthia			2/15 (13.3%)			2/15 (13.3%)
Peloponnese, Arcadia			3/6 (50.0%)	1/3 (33.3)	4/4 (100.0%)	8/13 (61.5%)
North Aegean, Lesbos	3/8 (37.5%)		3/16 (18.8%)	5/16 (31.3%)		11/41 (26.8%)
North Aegean, Lemnos			1/8 (12.5%)	1/4 (25.0%)	6/7 (85.7%)	8/19 (42.1%)
North Aegean, Ikaria		2/4 (50.0%)	2/5 (40.0%)			4/9 (44.4%)
TOTAL	**5/10 (50.0%)**	**11/23 (47.8%)**	**24/92 (26.0%)**	**13/42 (31.0%)**	**13/15 (86.7%)**	**66/182 (36.3%)**

ORAL 25

THERAPEUTIC POOLS IN REHABILITATION CENTERS IN GREECE: THE *FILOKTITIS* AQUATIC THERAPY MODEL

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Introduction
Last decade was the nascence for the development of Rehabilitation Centers in Greece. More than 10 Rehabilitation Centers provide multitude of services to inpatients and outpatients (Bilirakis 2015). An integral part of these services is Aquatic Therapy. Nowadays well-organized pools offer patients competent therapeutic protocols. However, there is a lack of specific legal regulations and guidelines regarding therapeutic pools in Greece.

Aims
This presentation aims at providing in a comprehensive manner the regulations, guidelines, and practices followed in *Filoktitis* Aquatic Therapy department the last years. Part of our aquatic therapy program is the continuous evaluation of the pools, based on established indicators (TEMOS, ISO). These indicators refer mainly to the level of infection observed in the pools (fecal, blood incidents, microbiological results, water balance chemistry, falls), and play a crucial role in infection control, illness and injury prevention, and disinfection, all of them being accomplished by means of specific standardized protocols. (APA, 2015)

Methods
Detail review of the components comprising the organizational model employed in the *Filoktitis* Aquatic Therapy Department. Analysis of official reports on objectives, goals and indicators of the therapeutic pool monitoring process applied between 2012 and 2016. Quantitative data regarding the evaluation process for monitoring the operation of the pools, according to ISO and TEMOS standards.

Results
The main components of the Filoktitis Aquatic Therapy Management Model are prescreening, corrective actions, illness and injury prevention, emergency action plans, maintenance, risk management, and education. Our therapeutic pool monitoring protocols showed that this model secures the reduction of biological factor incidence, the increase of pool maintenance effectiveness, the decrease of patient falls, the prevention of illness and injury, and the protection of all health professionals involved in the process. These improvements ensure the establishment of optimum conditions for better hydrotherapy.

Conclusions
The *Filoktitis* model of Aquatic Therapy appears to be competent compared to international standards. This competence includesoptimization of pool operation, better patient management, and greater achievement of therapy goals. Undeniably, there is a need for an update of the existing public codes

regarding the operation of swimming pools and other aquatic venues; especially for therapeutic pools in rehabilitation centers. Undoubtedly, a systematization of these codes into the public law will raise standards and reduce inspection violations (The Model Aquatic Health Code: www.cdc.gov/mahc).Future management topics and solutions for the therapeutic pools must be consistent with internationally established guidelines and quality certifications (Model Aquatic Health Code Annex ,CDC,2014).

ORAL 26

ASSESSMENT OF AIR AND WATER CONTAMINATION BY DISINFECTION BY-PRODUCTS IN THALASSOTHERAPY CENTERS

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Aims

Sea and spa water have been used for their curative and healing properties for thousands of years. Even Hippocrates suggested that the cause of all diseases lays in an imbalance of the corporal fluids. To regain the balance, he advised a change of habits and environment like bathing, perspiration, walking and massages. In the history of the Mediterranean people during the ancient Greek and Roman ages sea water was one of the most widely used therapeutic agents. “Sea water cures all human diseases” is a popular phrase from one of the tragedies of Euripides. A renewed interest in thalassotherapy (term coming from the ancient Greek word "θαλασσα") came in the middle of the 18th century, when the first Maison de Santé Thermale Marine (Seawater Bathing Spa) was opened at Dieppe, France in 1778. This practice now includes not only therapy, but also well-being and spa tourism, all over the world. Despite natural properties of seawater, pools within thalassotherapy centres or in spas are nonetheless treated with chlorine-based disinfectants to prevent outbreak diseases. However, as in swimming pools filled with tap water, continuous inputs of organic compounds from users leads to the formation of disinfection by-products, and because sea is rich in bromide, brominated disinfection by-products are expected. Moreover, because of the higher toxicity of brominated compounds as compared to their chlorinated analogues, determination of their amounts in air and water is highly relevant.

Methods

The speciation and levels of disinfection byproducts in air and water of 2 thalassotherapy centers having three indoor pools filled with seawater and treated with chlorine were monitored during Spring 2016. Several classes of DBPs including trihalomethanes (THM), haloacetic acids (HAA), haloacetonitriles, and trihaloacetaldehydes were analyzed in water, by Gas-Chromatography-Electron Capture Detection (GC-ECD), and analysis of total organohalogens was carried out by Extractable Organic Halide method (EOX). Global parameters such as Non Purgeable Organic Carbon (NPOC) and Total Nitrogen (TN), residual and total chlorine (bromine) were also performed. For the analysis of DBPs in air, canisters were used to sample air in the indoor pools, and analysed later in the laboratory with a proton-transfer-reaction time-of-flight mass spectrometry (PTR-ToF-MS).

Results and Conclusions

The mean (arithmetic) concentration of bromoform, dibromoacetic acid, tribromoacetic acid, dibromoacetonitrile and bromal hydrate in the three pools were 79.2, 72.9, 59.9, 26.9 and 10.0 µg/L, respectively. The maximum water level of THM (105.8 µg/L) exceeded 5-times the limit value recommended by the French Agency for Food, Environmental and Occupational Health and Safety (ANSES). By weight, HAA represented the most abundant chemical class followed by THM. In air, bromoform was the most abundant THM occurring at a mean concentration of 133.2 µg/m^3 in the three pools. The mean EOX level was 706 µgCl^-/L for the three pools. In average, the quantified DBPs accounted for only 14% of EOX, thus 86% of EOX remained unknown. These findings emphasize the need for further research to identify the halogenated DBPs with unknown nature and toxicity and for which users could be exposed to while swimming or in the context of an occupational exposure.

ORAL 27

PRESENCE OF PSEUDOMONAS AERUGINOSA AND CONTROL MEASURES IN THERMAL WATERS

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Objectives

Thermal waters in Colombia are utilized for recreational, therapeutic, and medicinal purposes, since they are claimed to benefit people's health by improving blood pressure, oxygenation or treating rheumatoid, breathing, and skin diseases. However, regulation for thermal waters to comply with minimum water quality standards in Colombia is still in a draft bill stage. As a result of this, it is necessary to pursue a study in both thermal waters pools and wells to determine the existence of this pathogen and the necessary control measures that need to be taken into account should it be detected.

Methods

For this study, 18 samples from three different adult thermal water pools were analyzed, they are located in Tabio, Guasca, and Choachí in the department of Cundinamarca, Colombia. pH, temperature, and *pseudomonas aeruginosa* were estimated. Sampling interval per pool was 15 days for a one-and-a-half-month period during vacations time (June and July), when most of swimmers attend these places. In situ measurements were done for pH and temperature parameters and *pseudomonas aeruginosa* in lab through Defined Substrate Technology (DST). In Colombia, regulations for use and utilization of thermal waters is in a draft bill stage through *Ley 62 de 2015*, which aims at promoting, fostering, regulating, directing, and controlling the therapeutic and touristic usage of thermal resorts and the use of thermal waters. Nevertheless, it does not refer to water quality ranges at the microbiological level, turning this into an unexplored field in Colombia. Microbiological results were assessed from the established ranges for resorts by the World Health Organization (WHO), regulations in countries such as Cuba, and the autonomous regions of Galicia, Murcia, and Catalunya in Spain, since no regulations are in effect in Colombia.

Results and Discussion

Physical and microbiological tests

Temperature: Thermal water sources analyzed showed temperatures between 38°C and 50°C which classifies them as mesothermal waters, range 35°C and 50°C, closing into a hyperthermal condition.

Ph: pH of thermal sources analyzed showed a range between 6.0 and 7.10 and pools showed a range between 6.61 and 7.70 which classifies them as acid and alkaline thermal waters.

Pseudomonas aeruginosa: Tests showed the presence of *Pseudomonas aeruginosa* in 1 out of 3 analyzed wells and 2 out of 3 analyzed thermal water pools. In those pools where the pathogen was found the concentration varies between 2 UFC/100ml and 67 UFC/100ml and the variation in the well is between 12 UFC/100 ml and 99 UFC/100ml.

Correlation between pH and Pseudomonas aeruginosa

At Guasca's thermal resort, where the well's pH varies between 6.00 and 6.17 and the pool's between 6.40 and 6.62, it was found that pathogen concentration is below 1 UFC/100ml. At Choachí's thermal resort, the well's pH varies between 6.80 and 6.93, it was found that pathogen concentration is below 1 UFC/100ml. On the other hand, the pool's pH varies between 7.30 and 7.54 and pathogen concentration is between 2 UFC/100ml and 67 UFC/ 100ml. Finally, at Tabio's thermal resort, the well's pH varies between 7.00 and 7.10, it was found that the pathogen concentration is between 12 UFC/100ml and 99 UFC/100ml. The pool's pH varies between 7.18 and 7.70 and pathogen concentration is between 1 UFC/100ml and 11 UFC/ 100ml. From the samples analyzed in Tabio, Guasca, and Choachí, both in pools and wells, the presence of *Pseudomonas aeruginosa* prevails when the substance is classified as alkaline, that is, pH levels above 7.0.

Pseudomonas Aeruginosa and regulation in thermal waters

Based on the established ranges for *Pseudomonas aeruginosa* in regulatory standards in Cuba, WHO, Galicia, Catalunya, and Murcia in Spain, an assessment of the results from wells and pools was performed.

Swimmers and determination of control measures

There are multiple and varied contaminating agents of pool water and can come from previous water contamination, lack of or poor cleaning of pools and dependences, accessory materials immersed in the pool and **mainly from users themselves.** Preventing the contamination of water and its surroundings in treatment pools and the struggle against the development of infectious agents is strictly based on the compliance of: hygiene and cleaning protocols of swimmers, pools, facilities, and attached commercial establishments.

Conclusions

- *Pseudomonas aeruginosa* is present in 1 out of 3 thermal water wells analyzed, as a hypothesis it is stated that such contamination can be associated to the inadequate protection of the aquifer or waste discharge onto the thermal water spring.
- The concentration of *Pseudomonas aeruginosa* is below 1 UFC/100ml in wells with a pH level under 7.00, while for pH levels above 7.00 this concentration becomes countable.
- 67% of thermal water samples taken from the supply wells comply with the established ranges in consulted regulations, while 56% of pool samples comply with regulations.
- Overall, out of eighteen analyzed samples (from pools and wells) only 61% of them comply with consulted regulations.
- To control contamination, it is necessary to implement a control and access protocol that considers medical, hygiene, and use restrictions.

ORAL 28

REGISTRATION OF THE LEVEL OF ADJUSTMENT AND FUNCTION IN THE AQUATIC ENVIRONMENT OF CHILDREN WITH CEREBRAL PALSY DURING THE PERIOD 2016-17.

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Aims
The purpose of this study is to register and valuate the level of adjustment and functional abilities of children with Cerebral Palsy (CP), who participated in the program of therapeutic swimming in ELEPAP Athens during the period 2016-17. The level of adjustment and function in water was associated with the functional level on the ground. The long-term goal of this registration is to create a database in order to monitor the motor development in water and to investigate the effectiveness of therapeutic swimming based on the Halliwick concept.

Methods
SAMPLE: 49 children with cerebral palsy aged 2-8 years were eligible for this study out of a total of 103 children who participated in the program of therapeutic swimming in ELEPAP Athens during the period 2016-17. ELEPAP is the largest rehabilitation center in Greece offering intervention programs for children with neurodevelopmental problems. The children were divided into two age groups: a) children of 2-4 years of age and b) children of 4-8 years of age.

Assessment Tools
The level of functional ability in water was evaluated with the Water Orientation Test of Alyn (WOTA) 1 or 2. Wota is a valid and reliable tool for the assessment of functional independence in the aquatic environment. It is designed for swimmers with functional and cognitive limitations and it is based on the principles of the Halliwick concept. Wota 1 is designed to evaluate the swimmer's mental adjustment and function in the water targeting at swimmers with difficulties in understanding and following instructions as well as swimmers of a young age. Wota 2 is similar to Wota 1 but it is designed for swimmers who can follow instructions. The Gross Motor Function Measurement (GMFM-88) was used for the assessment of gross motor ability on the ground. Finally, the Gross Motor Function Classification System (GMFCS) was used in order to categorize children with CP according to their functional level. All measurements took place from December 2016 until the end of January 2017. All children were evaluated with GMFM-88 and GMFCS. Wota 1 was used to evaluate 18 children aged 2-4 years (GMFCS I-V) and 10 children aged 4-8 years (GMFCS IV-V). Wota 2 was used to assess 21 children aged 4-8 years (GMFCS II-IV).

Results
According to the results there is high correlation between the functional level (GMFCS) and gross motor ability (GMFM) on the ground, while there is no high correlation between the functional level

on the ground and the functional level in water based on tests Wota 1 &Wota 2. More specifically, children aged 2-4 years with GMFCS 5 and mean score of GMFM 8,41% and children aged 4-8 years with GMFCS 5 and mean score of GMFM 11,19%, appear to have higher functional level in the water according to Wota 1 mean score 36,34% and 36,2% respectively.

Conclusions

The level of adjustment and function inside the water for children with CP proved not consistent with their motor skills on the ground (gravity). It also appeared that cognitive functions, personal and other environmental factors play an important role in motor performance and functionality of children in a multisensory aquatic environment.

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ORAL 29

THE UK POOL WATER ADVISORY GROUP (PWTAG) UPDATED HYDROTHERAPY POOL GUIDELINES

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Aims

Hydrotherapy pools are warm water pool designed for aquatic physiotherapy treatment and rehabilitation. They are used to treat people post injury, surgery, or for medical condition management and so they need to designed and managed to facilitate safe access for those with many types of mobility impairment and a range of equipment needed for safe movement, showering, pool access and treatment. The current hydrotherapy pool guidelines were written some time ago and no longer reflect the current range of uses of hydrotherapy pools or the changes to a more risk based design, operational and management regime. Independent audits of hospital pools have generally raised many concerns about how the pools were designed and managed, with many not even meeting the current guidelines. These updated guidelines give advice on better design, improved governance, operational management and include a risk based approach to the use of pools for other uses such as baby swimming. The aims of the new guidelines are to make hydrotherapy pools safer for both users and aquatic therapists.

Methods

The Guidelines were developed by a multidisciplinary group with practical experience in aquatic therapy treatment, microbiology, healthcare governance and the development of Water Safety Groups (WSG) and Water Safety Plans (WSP).

Results

The resulting guidelines now reflect best practice for design, governance especially in healthcare settings, operational management based on the WSP approach as advocated by WHO with a multidisciplinary WSG having oversight on operational management; monitoring and appropriate remedial actions. The WSP includes a more risk based approach to patient treatments which includes a written scheme of control drawn from the findings of a formal risk assessment. The risk assessment identifies what is required to be included within the pool management regime including the monitoring and surveillance requirements and supporting programmes. The latter includes identifying the training needs for all staff involved in treatment and pool management, reviewing method statements, internal and external audits and ensuring there are effective lines of communication. The Guidance also now considers the needs, within the current financial restraints, of pools to be cost effective and allowing other non-patient groups access to the pool and facilities; however such groups such as baby swim classes can put an unacceptable strain on the pool disinfection if not designed and managed appropriately. The guidance includes a check list for hydrotherapy pool owners / managers to consider before allowing such use.

Conclusions

Good hydrotherapy pool design for aquatic therapy requires additional factors to be taken into consideration over and above those required for a normal recreation swimming pool. These pools are warm as the ideal temperature for a hydrotherapy pool is thermoneutral (34-35°C) which is the temperature range where the body's core temperature will not increase or decrease. However at this temperature microbial contaminants such as *Pseudomonas aeruginosa* can grow to levels which may cause infections. Aquatic therapists also spend long periods of time in the pool so the pool water quality needs to be optimum to reduce the risk of infection to both the therapist and the pool users.

Patient risk factors also include the increased vulnerability to infections of patients who may be immunocompromised or have open wounds, including external fixator frames, or may be incontinent etc. Patients also need to be risk assessed and treatments organised based on the vulnerability to infection and the risk of inadvertent contamination of the pool. The design also needs to consider the flow through the pool and the additional space requirements needed for aquatic therapy for example space to store wheelchairs; walking aids, trolleys etc. both prior to the changing area and poolside.

Before a decision is made as to whether the pool is safe both to the external user groups and the therapists and patients who subsequently use the pool a risk assessment must be carried out which takes account of the facilities e.g. Suitable provision for prams; nappy changing, a suitable treatment regime to reduce the risk of pool acquired infections especially from *Cryptosporidium*. Following the guidelines will ensure safer and more user friendly hydrotherapy pools. The presentation will include an overview of the updated guidance and the results of some of the audits which led to its development.

Session V

Chlorination byproducts

CHAIR: *Henrik R. Andersen, Guglielmina Fantuzzi*

ORAL 30

CHLORINATION BY-PRODUCTS FORMATION IN INDOOR SWIMMING POOLS: DEVELOPMENT OF A PILOT POOL AND ASSOCIATED KINETIC STUDY

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Aims

Chlorination by-products (Cl-DBPs) concentrations in indoor swimming pools are influenced by many parameters which are difficult or impossible to control when performing on-site experiments. To further investigate the influence of operational parameters on Cl-DBPs formation in swimming pools, a research program has been set up. The program includes the development of a pilot pool to perform reproducible experiments under controlled operating conditions (bather load, water flow rate, water temperature etc). This first study aims at validating the representativeness of the pilot unit compared to French indoor swimming pools. A complementary kinetic study is conducted in batch reactor to understand more deeply the chlorination kinetics of the Body Fluid Analog (BFA) used to reproduce the bather load [1].

Methods

The pilot pool is a $40m^3$ basin (1/10 scale) equipped with a system which reproduces the bathers behavior and which distributes the BFA. The water recirculation and the air flux above water are controlled. The water treatment system is typical of indoor swimming pools and consists of a sand filter followed by on-line regulations for chlorine and pH. A 3-week sampling campaign is performed during which water and air samples are collected twice a day. The concentrations of 9 Cl-DBPs in water are monitored by GC-MS. The chloroform concentration in the air is measured.

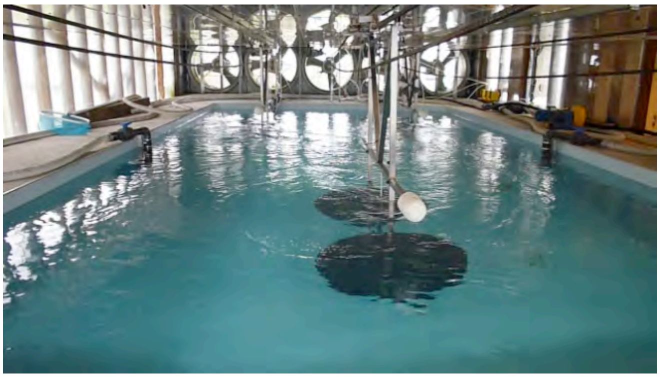

Figure 2 The pilot pool

For the kinetic study in batch, diluted BFA solutions are chlorinated at different initial chlorine doses and in different matrices (ultra-pure water, tap water etc). Chlorination experiments are performed in head-space free bottles which are kept at 27°C. The pH is set at 7.2 by a phosphate buffer. Free and combined chlorine as well as Cl-DBPs concentrations are monitored for reaction times up to 2000h.

Results

Concentrations measured in the pilot pool water are in the same range as the values usually reported from measurements in French public swimming pools [2], which validates the BFA composition and flux. Moreover, periodic variations of volatile Cl-DBPs concentrations in water due to bathers' activity are observed. Same variations have been reported from studies in real swimming pools [3], supporting the pilot ability to reproduce human behaviors influencing the Cl-DBPs water-to-air transfer. Measurements in air are less satisfactory due to air temperature variations, high sampling times and high air exchange rate. Kinetic studies show that many Cl-DBPs, particularly chloroform and haloacetic acids, continue to be formed for reaction times longer than 500h. Individual contributions of BFA's components are analyzed as well as the influence of bromide and hypobromite ions concentrations in the filling water. These data are involved in the building of a kinetic model.

Conclusions

Convenient operational conditions are determined for the simulation of French indoor swimming pools. The improvement of the air recirculation in the pilot hall will enable the study of the water-to-air transfer of volatile Cl-DBPs. The kinetic study highlights important individual contribution of the BFA components. First chlorination kinetic models are calibrated and validated using batch chlorination experiments under different operating conditions. Coupling these results with water-to-air transfer models and hydrodynamic study should enable the building of prediction models for exposure assessment [4].

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ORAL 31

OPTIMISED VENTILATION FOR INDOOR SWIMMING POOLS BY AN INTELLIGENT REAL-TIME CONTROL SYSTEM

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Effective ventilation maintains the comfort and health of the swimming pool occupants; it also ensures the upkeep of the building fabric and its structural integrity. A recent 2.3 million Euro EU consortium funded research project, Intellipool, has evaluated the degassing of disinfection by-products (DBP) from the pool water as a function of real time bather loads, pool water treatments, 3D flow fields in the pool water, as well as pool activity levels.

Aims

An intelligent air control system is then developed for improved inlet/outlet ventilation designs and smart clean air operation by adjusting fresh and recirculation air flow rates and mixing ratios after taking into account pool hall and outdoor air temperature and humidity. This is to maximise clean air delivery across the pool hall, to maintain comfortable temperature and relative humidity, and to optimise the removal of airborne contaminates (e.g. chloroform emission). Leisure centres are one of the most energy intensive buildings to operate, and over 50% of these energy costs can be directly attributed to heating the air space in the swimming pool hall and adjoining changing areas. The use of such intelligent systems can significantly reduce the overall energy consumption and environmental cost, with comprising bather comfort and building fabric protection.

Methods

To model the level of DBPs in the pool hall air, the intelligent real-time control system considers psychrometric air processes, the real-time pool occupancy, chemical kinetics for DBP formation, pool activity which causes disturbance of the water surface and therefore determines the rate of degassing, pool water and pool hall air 3D flow information, pool and air filtration systems efficiencies. The 3D flow information was obtained from 3D Computational Fluid Dynamics (CFD) simulations for the pool water and pool hall air environments, and translated into Residence Time Distributions (RTD) curves to allow for the spatial variations while reducing the computational complexity of the real-time system. Using heat recovery systems within the air handling unit (AHU) recovers energy from the exhausted air to fresh air, enables intelligent control logics to regulate the humidity, the temperature, the levels of DBPs and CO_2 in the pool hall by mixing an optimal amount of air recirculated from the pool hall with the required outdoor fresh air to supply to the pool hall inlets. The rate of recirculation can also be further increased by the use of TiO_2 filtration increasing the removal rate of DBPs.

Results

As a case study, the air control settings to achieve desirable swimming pool environment and air quality with a conventional ventilation design is compared with that of an improved design. The energy consumption in the improved design are quantified for 7 typical consecutive UK summer days, and for 7 typical consecutive UK winter days assuming (i) no heat recovery, (ii) heat recovery, and (iii) intelligent heat recovery enabled by DBP filtration and smart automated air recirculation.

Conclusions
It demonstrates that good ventilation designs and the operation of the AHU can be justifiably optimised to improve air quality, whilst at the same time achieving substantial savings in energy and environmental costs. The ability to visually compare existing systems and designs to new intelligent methods provides all stakeholders better information to make more informed decisions about client comfort, energy costs and capital investments.

ORAL 32

DESTRUCTION OF DBP_S AND THEIR PRECURSORS IN SWIMMING POOL WATER BY COMBINED UV-TREATMENT AND OZONATION

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Highlights

- UV treatment increased the reactivity of pool water to both chlorine and ozone
- Ozonation of UV-treated water decrease chlorine reactivity
- Genotoxic trichloronitromethane formed by ozonation was removed with UV treatment
- Continuous UV/ozone treatment decreases chlorine by-product formation
- Continuous UV/ozone treatment predicted to improve chlorinated pool water quality

Aims

The aim of the current study was to investigate the effect of a combined treatment system on DBP formation. As both ozone and chlorine preferably react with electrophilic groups in compounds [1], [2], we hypothesise that reactivity to chlorine, created by the UV treatment of dissolved organic matter in pool water, might also mean that there is increased reactivity to ozone and that ozonation might remove the chlorine reactivity created by UV treatment. Therefore, we first performed an experiment to range-find the effect of swimming pool water UV activation on chlorine reactivity. Second, an experiment was carried out to characterise the effect of adding various doses of ozone to pool water, with or without UV pre-treatment, before chlorination to study the effect on chlorine reactivity and the formation of chlorination by-products. Finally, the possible effect on chlorination by-product formation was investigated by a repeated, combined UV-ozone treatment interchanged with chlorination (repeated cycles of UV followed by ozone with subsequent chlorination). Toxicity estimation was used to evaluate water quality.

Methods

- UV treatment

  Treatment was conducted using a quasi-collimated beam apparatus with a doped, medium pressure lamp (P = 700 W, ScanResearch, Denmark). To ensure constant spectra and emission output, the lamp was turned on half an hour before the experiment. Petri dishes (350 mL) were used as reaction vessels, while samples were maintained headspace-free and covered by a disc of quartz glass, to limit the volatilisation of the treated sample. To ensure homogeneity during irradiation, samples were mixed gently with a stirrer. The UV dose was determined according to a method described by Hansen et al. [3]. In summary, UV exposure in the collimated beam set-up was correlated to a real flow-through system on a pool, using the removal of combined chlorine. The UV system needs 1.0 kWh/m^3 to remove 90% of the combined chlorine. For the collimated beam set-up, required radiation time to remove 90% of the combined chlorine from the pool water was 12.3 mins.
- Ozonation

Ozonation was achieved by adding an amount of ozone stock solution to a water sample which resulted in maximum 10% dilution of the sample and the concentrations were back calculated according to actual dilution. Ozone dosage was determined by adding a sufficient amount of potassium indigotrisulfonate and a phosphate buffer to a separate ultra-pure water sample and measuring the absorbance of the unreacted indigotrisulfonate. A detailed description can be found in Hansen et al. [4].

- Chlorination
  The formation of DBPs as a result of chlorination was investigated using a standardised DBP formation assay. The effect of chlorine concentration in the assay was also recently investigated by Hansen et al. [5]. In the current study, the same approach was used to simulate chlorination in the pool after the return of UV/ozone-treated water. Water samples were transferred to 40 mL glass vials after treatment in which chlorine and boric acid were added based on the chlorine consumption determined in pre-experimental tests. The aim was to have 1 ± 0.3 mg Cl_2/L after 24 hours at 25ºC (measured by ABTS). Chlorination was performed in quintuplicate, with three samples used for DBP analysis and two for the determination of residual chlorine. Samples for DBP analyses were dosed with ammonium chloride solution (50 mg/L), to quench free chlorine which neither affects the already formed DBP [6] nor increases N-DBP formation [7]. The samples were analysed the same day.

Results

We found that UV treatment makes pool water highly reactive to ozone. The created reactivity towards chlorine decreases dose dependently with ozone dosage prior to contact with chlorine. Furthermore, the kinetics of ozone in UV treated pool water changed significantly from a half-life of 5 min to complete consumption in less than 2 min. Ozonation of UV treated pool water induced formation of some DBPs that are not commonly reported in pool water where trichloronitromethane is noteworthy for its genotoxic. However, this created genotoxicity was removed by UV treatments when repeated combined UV/ozone treatment interchanged with chlorination for 24h were conducted. The discovered reaction can form the basis for a new treatment method for swimming pools. The schematic of the proposed system has been shown in figure-1.

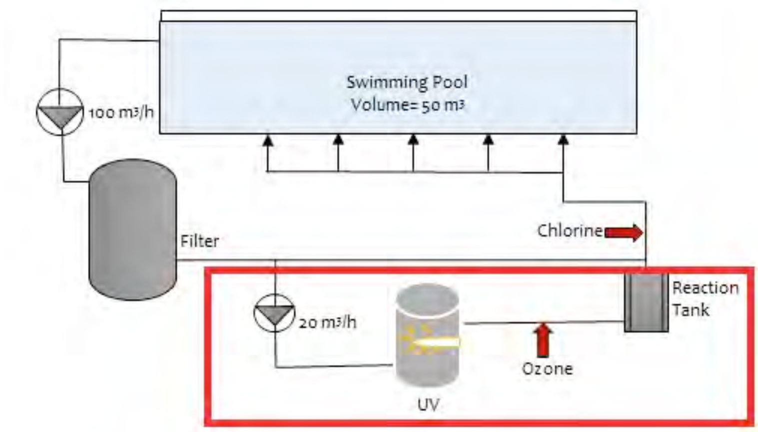

Figure 1: Schematic of proposed system

Conclusions

The treatment of swimming pool water by means of UV irradiation increased chlorine demand. Furthermore, the ozonation of pre-treated UV-irradiated pool water subsequently removed chlorine demand and decreased DBP formation. Combined treatment effectively reduced the level of disinfection by-products in pool water except for trichloronitromethane where an increase was observed. Trichloronitromethane was reduced after repeated treatment cycles and thus UV/ozone treatment is predicted to improve swimming pool water quality.

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ORAL 33

EFFECT OF UV TREATMENT ON DBPS FORMATION IN CHLORINATED SEAWATER SWIMMING POOLS- A LABORATORY STUDY

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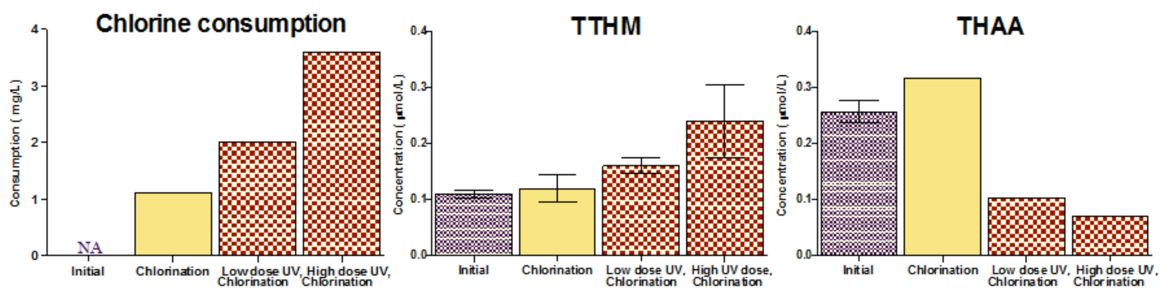
Highlights

- UV treatment increased the reactivity of seawater pool water towards chlorine
- UV treatment reduces haloacetic acid concentrations after re-chlorination
- Post-UV chlorination increases trihalomethane and haloacetonitrile concentrations
- Increase in concentrations predicts higher toxicity after single UV treatment and chlorination

Graphical abstract



Aims

The aim of this study was to investigate the effect of UV treatment followed by chlorination on DBP formation was studied using laboratory experiments. Three groups of DBPs were investigated including THMs, HANs and HAAs. DBP level measured after post-UV chlorination was compared to dark control sample which was not subjected to UV exposure. Bromine substitution was investigated to analyse its effects on the formation of DBPs. Finally, overall cytotoxicity and genotoxicity were estimated for the toxic potency of compounds before and after treatment.

Methods

UV treatment

Batch experiments were conducted by using a thermostatic controlled cylindrical reactor with a standard medium-pressure UV lamp (P=700 W, Peschl Ultraviolet). In this work, UV dose was determined according to method described by Hansen et al. [1]. UV exposure cylindrical reactor setup was correlated to the real flow through system on the pool by using combined chlorine as an actinometer. UV system needs 1.0 kWh/m^3 to remove 90% of combined chlorine and 0.61 kWh/m^3 to remove monochloramine [1]. The required radiation time for the cylindrical reactor setup to remove 90% of the monochloramine from the pool sample was 4.2 min (2.1 J/cm^2).

Chlorination

The formation of DBPs as a result of chlorination was investigated using a standardised DBP formation assay. The concentration of free chlorine was adjusted to 3.0 ± 0.05 mg/L by adding sodium hypochlorite solution and then the sample reacted for 24 h at 25 °C. Chlorination was performed in quadruplicate, with three samples used for DBP analysis and two for the determination of residual chlorine. Samples for DBP analyses were dosed with ammonium chloride solution (50 mg/L), to quench free chlorine which neither affects the already formed DBP [2] nor increases N-DBP formation [3]. The samples were extracted and analysed for DBPs the same day.

Results

Chlorine consumption increased with post-UV chlorination likely because UV irradiation degraded organic matter in the pool samples to more chlorine reactive species. Haloacetic acids (HAA) concentrations decreased significantly due to photodegradation. However, concentration of trihalomethanes (THM) and haloacetonitriles (HAN) increased with post-UV chlorination. Bromine incorporation in HAA was significantly higher in control samples chlorinated without UV irradiation but decreased significantly with UV treatment. Bromine incorporation was promoted in THM and HAN after UV and chlorine treatment. Overall, the accumulated bromine incorporation level in DBPs remained essentially unchanged in comparison with control samples after post-UV chlorination. Toxicity estimates increased with single dose UV and chlorination mainly due to the increased HAN concentrations. However, brominated HANs are known in literature to be degraded with further UV treatment.

Conclusions

The present study is the first to investigate the fate of brominated DBPs submitted to medium-pressure UV lamp followed by post-chlorination, on real seawater swimming pool samples. Firstly, UV treatment is an efficient method to decrease the combined chlorine level in swimming pools. However in seawater pools, UV treatment has a potential to photodegrade the DBP as brominated DBPs are easier photolysed than the chlorinated ones [1]. The results obtained in this study show that the UV treatment followed by chlorination does not lead to real abatement in DBP content. Only levels of dibromoacetic acid and dibromochloroacetic acid were significantly lowered, whereas levels of bromoform, dibromochloromethane, bromochloroacetonitrile and dibromoacetonitrile increased. These findings have also to be correlated to the observed increase in estimated cytotoxicity and genotoxicity in the whole real samples submitted to UV treatment followed by chlorination. This increase in toxicity can be attributed to increase of levels of DBPs, and especially of HAN [4]. This study raises thus the issue that UV used for combined chlorine reduction could result in increased formation of some of brominated DBPs in seawater swimming pools. However, further studies are still needed to interpret present findings, including influences of composition of water, UV dose rate, UV wavelength and, chlorine dose on the kinetics of brominated DBP formation or disappearance.

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ORAL 34

HALOGENATED DISINFECTION BY-PRODUCTS (DBPs) IN INDOOR SWIMMING POOL

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Introduction

Disinfection of drinking water and swimming pool water is crucial for the inactivation of pathogens (Geldreich, 1989; USCDC, 1997;MOE, 2002; MWH, 2005; CDC, 2007; HaitiLibre, 2010). The most used disinfectants in swimming pools are chlorine and bromine (Bessonneau et al., 2011). However, disinfection by products (DBPs) are formed in indoor swimming pool water as a result of disinfectant and organic matter reaction in swimming pool. There are two organic matter origins in pool water, one is the natural organic matter (NOM) already present in the filling water, and the other is the organic matter released from swimmer's bodies (human excretions or body fluids (BF)) (Hang et al., 2016). Trihalomethanes (THMs), haloacetonitriles (HANs), haloaceticacids (HAAs), halonitromethanes (HNMs), chloral hydrates (CH), cyanogen chloride etc. are the most halogenated by products that have been in swimming pools water (Kanan, 2010; Kanan and Karanfil, 2011; Chowdhury et al., 2014; Kanan et al., 2015). The aim of this study is to monitor the occurrence of DBPs and adsorbable organic halides (AOX) in a public swimming pool water in Isparta/Turkey.

Materials and Methods

Samples were obtained weekly for about one year. Municipal already chlorinated groundwater was used as filling water in the pool. Different pool water characteristics (temperature, pH, dissolved oxygen, conductivity, salinity, residual free chlorine (FC), and residual total chlorine (TC)) were determined instantly upon sampling. Furthermore, samples were transferred to the lab for DBPs (THM_4, HAA_9, HAN_6, HNM_9), TOC, AOX, UV_{254nm} absorbance, bromide, nitrite, nitrate, ammonium and total nitrogen (TN) analyses.

Results and Discussion

Over a one year monitoring, around 1,350 bathers used the pool weekly. At the end of the sampling period about 65,000 bathers used the investigated pool. The average FC, combined chlorine, and TOC of the pool water along the sampling period were 0.4 mg/L, 0.2 mg/L and 1.5 mg/L respectively. $SUVA_{254nm}$ values were <2.0 L/mg-m, indicating that organic matter is mainly non-humic and hydrophilic. Total THMs concentration in the pool water samples ranged between 10 and 44 µg/L with an average of 20 µg/L while total HAAs ranged between xx and yy µg/L with an average of 55 µg/L. Chloroform (96%) was the dominant THM, while thrichloroacetic acid (50%) and dichloroacetic acid (45%) were the dominant HAA. HANs and HNMs were lower than minimum reporting level (MRL=1 μg/L). AOX concentrations in all samples ranged between 175 and 560 μg/L.

Conclusions

TOC levels of the pool water were relatively low due the pool the continuous water replenishment. This ended with low amount DBPs and AOX occurrence. Chlorinated species dominated over brominated ones due the very low ambient bromide in the pool water.

Acknowledgment

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ORAL 35

COMPARISON OF TRIHALOMETHANES IN THE AIR OF TWO INDOOR SWIMMING POOL FACILITIES USING DIFFERENT TYPE OF CHLORINATION AND DIFFERENT TYPES OF WATER

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Background
Chlorine-based water treatment is the most common disinfection used in swimming pool water. The method reduces the risk of exposure to pathogens present in the water such as bacteria, parasites and fungus. If these pathogens are not removed, they can cause severe health effects and even death. The reaction between chlorine and organic matters from the occupants such as hair, lotions, mucks, skin extraction and urine creates disinfection bi-products (DBPs). The presence of DBPs in the poolroom has been linked to a variety of health issues. Among the most important groups within DBPs are trihalomethanes (THMs), where chloroform ($CHCl_3$), bromdichlormethane ($CHBrCl_2$), dibromochloromethane ($CHBr_2Cl$) and bromoform ($CHBr_3$) are most abundant. Of the four THMs, chloroform is the compound that has received the most attention in the literature, but adding saltwater in the pool increases the amount of brominated DBPs making bromoform the most dominant THM. Another factor increasing the amount of brominated DBPs in swimming pool water is using sodium hypochlorite for water disinfection. Exposure occurs mostly through inhalation and dermal contact in swimming pools. Occupants in the pool inhale more concentrated air in comparison to employees and visitors staying by the poolside. Besides that, the employees and athletes will be more exposed because of a longer exposure time. In former studies, stationary air samples have been collected mostly from freshwater pools using a low flow pump located from 0.3 m to 1.5 m above the floor level and 1.5 m from the pool edge. These samples do not represent the concentration in the breathing zone of the occupants in the pool. To determine health effects related to the different activities in the pool, it is crucial to measure the concentration of THMs directly above the surface of the water as high activity provides high pulmonary ventilation.

Aims
The aim of this study is to

1. Measure the concentration of THMs 0.05 m, 0.6 m and 1.5 m above the pool water surface.
2. Compare the distribution of THMs from three freshwater pools and one seawater pool using different disinfection principles.
3. Investigate if bromoform can function as a biomarker for THM in pool facilities when using saltwater in the pool.

Methods

Four swimming pools in Trondheim, Norway, located in two different public indoor swimming facilities were selected for the study. The choice of these two facilities makes a comparison possible, as one of the facilities uses granulated calcium hypochlorite for disinfection treatment while the second one uses liquid sodium hypochlorite in addition to UV-lighting. The latter has one pool containing 30 % saltwater. Air samples are obtained by pulling air through stainless steel tubes containing 0.20 g of Tenax TA 35/60 (Markes International), using low flow pumps with an average flowrate of 50 ml/min for 20 minutes. This is in accordance with recommendations of the standard method US EPA TO-17 and Markes guide 086. Three samples are collected simultaneously using a test stand with three different heights; 0.05 m, 0.6 m and 1.5 m above the pool water. Samples are collected during morning swim, baby swimming in the afternoon and during public swimming in the evening. These activities are equal for both facilities. Tube number and placement, pool activity, free chlorine, combined chlorine, pH, air- and water temperature, number of occupants and relative humidity are registered during each sampling session. Agilent Technologies 5975T LMT-GC/MSD are used to analyze THM in the air. Desorbed substance is injected through a split/splitless injector (split mode 0.7:3.7) into a capillary column (DB-1; ID 0.25 mm and 0.25 µm film thickness). The temperature program is running from 35 °C to 90 °C with 5 °C/min steps with post run at 230 °C. For quality assurance, six samples are being sent to an external and ISO accredited laboratory (SINTEF MOLAB AS).

Results

The study is not finished, but so far, 42 of 93 samples have been collected and analyzed. The result of this study will help determine the actual levels of THM in the breathing zone during swimming or walking by the poolside. Later, these results can be used to establish health based guidelines for accepted exposure limits for THMs in the air of indoor swimming pools using seawater and different chlorine-based disinfectants for water treatment. In addition, a measurement strategy will be proposed.

Conclusions

As stated above, the study is still ongoing and therefore, conclusions cannot be drawn yet. However, the analyzed samples show promising results to be used as a basis for the anticipated proposals. The sampling and sample analyses will be completed within three weeks, i.e. in due time to prepare the full conference paper as outlined above.

ORAL 36

CRITERIA TO CHOOSE ACTIVATED CARBON THAT CONVERTS MONOCHLORAMINE TO MOLECULAR NITROGEN

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Introduction

Inorganic chloramines in swimming pool water are disinfection by-products (DBPs) primarily resulting from the chlorination of ammonia (NH3) and urea (NH2CONH2). Among the variety of known DBPs, the occurrence and toxicological relevance of inorganic chloramines is studied frequently. Chloramines have recently received even more and particular attention because they were found to react with dimethylamine (DMA) forming highly carcinogenic N-nitrosodimethylamine (NDMA). Consequently, the removal of chloramines from the aqueous phase is highly relevant for swimming pool water treatment. At neutral pH conditions and typical Cl:N ratios of swimming pool water, monochloramine is known to be the most dominant species among the inorganic chloramines. Its concentrations in pool water are reported up to 1.88 mg L-1 (as Cl2). Previous studies indicate that monochloramine is reduced to ammonium (NH4+) at granular activated carbon (GAC) surfaces, by oxidation of free surface sites C* (Equation 1). Also, reduction of chloramine to N2 can occur at GAC surfaces, by reduction of oxidized surface sites C*O (Equation 2).

NH2Cl + 2 H2O + C* → NH4 + + 2 H+ + Cl- + C*O (1)

2 NH2Cl + C*O → N2 + 2 H+ + H2O + 2 Cl- + C* (2)

As swimming pool water is continuously circulated and rechlorinated, all ammonia produced in the reaction according to equation (1) will again be transformed into chloramine. Therefore, treatment of swimming pool water with GAC is ineffective with respect to the overall chloramine balance, if no chloramine reduction to N2 occurs. A proportion of chloramine as high as possible to be converted to nitrogen according to equation (2) is desirable. Consequently, criteria to choose the right carbon are needed.

Methods

In our study, yields of NH4 + and N2 for monochloramine reduction at different commercially available granular activated carbons (GACs) were determined in fixed-bed column studies over a long period of time. Experiments showed that, depending on the type of GAC used, the N2 yield of the monochloramine reaction ranged between 0.5 % - 21.3 %. Chemical properties of the GACs, such as the concentration of acidic oxide surface groups and elemental compositions, were analyzed and correlated with the observed N2 yield of the reaction. Four commercially available GACs, Hydraffin 30N from Donau Carbon GmbH (30N), Centaur from Chemviron Carbon GmbH (Centaur), Silcarbon K-835 from Silcarbon Aktivkohle GmbH (K835) and Saratec 100058 from Bluecher GmbH (100058) were used in this study. The raw materials of the carbons were anthracite coal (30N), coconut shells (K835), bituminous coal (Centaur) and non-porous polymer-based spheres (100058).

Results

Figure 1(A-D) shows the amount of substance of NH4+ produced and the observed reaction rate constant keff over the amount of substance of monochloramine degraded at the bench scale GAC filter using filter beds of the 30N, K835, Centaur, and 100058 carbon. In agreement with previous findings, keff initially decreased until stationary conditions were reached, which was after 0.75 to 1.25 mmol gGAC-1 of monochloramine reacted (equal to 75 - 125 h of filter run time). The reaction rate constants keff at steady state revealed in the following order: 0.015 s-1 (100058) < 0.016 s-1 (30N) < 0.018 s-1 (K835) < 0.024 s-1 (Centaur). The N2 yields were as follows: 21.3±4.1 % (K835) > 11.6±3.1 % (100058) > 4.2±3.0 % (Centaur)> 0.5±4.7 % (30N). Slightly higher values for the N2 yield were reported in previous fixed-bed column studies (42 %, 23 to 40 % and 27.3 %). Contrary to the findings of Fairey et al. (2007), hypothesis testing (p<0.05) in this study showed that the differences in N2 yield between the tested GACs were significant.

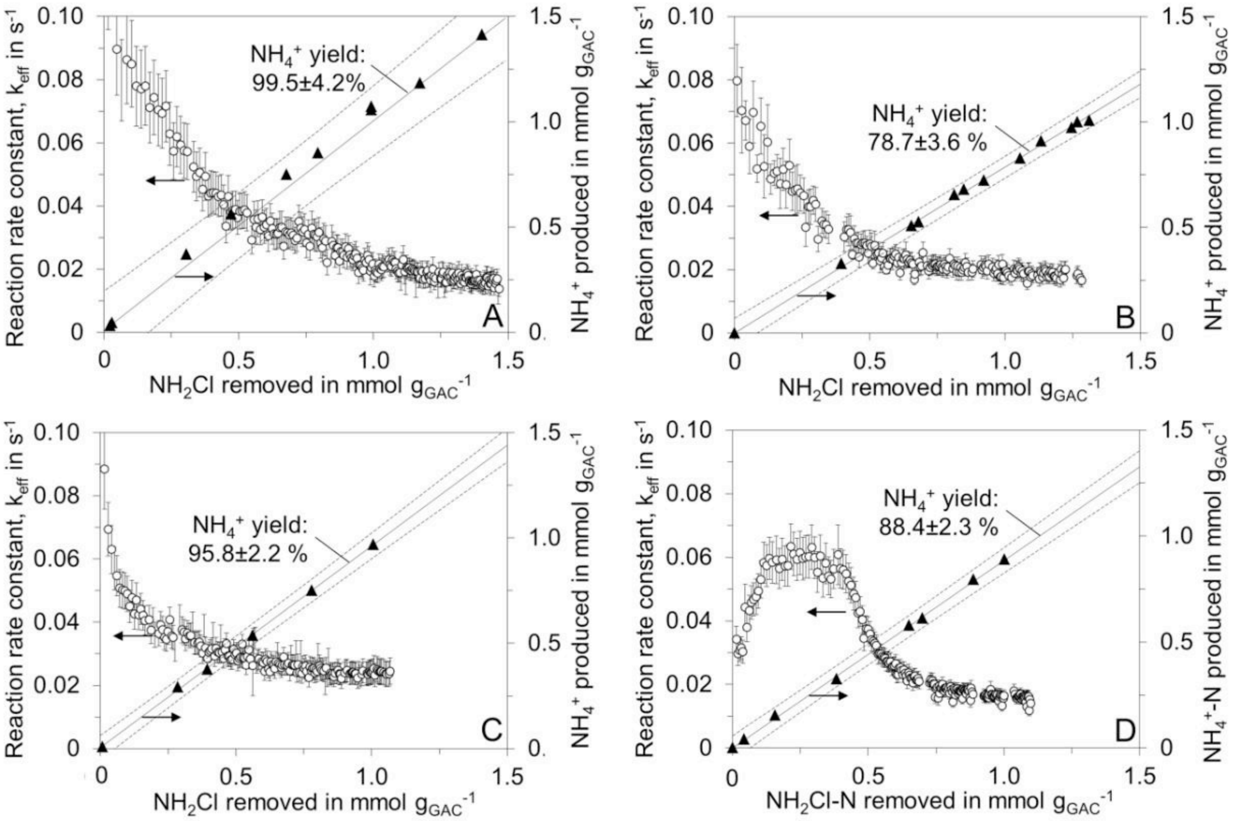

Figure 1: Reaction rate constant and amount of substance of NH4+ produced versus the amount of substance of monochloramine removed for the GACs 30N (A), K835 (B), Centaur (C) and 100058 (D). The NH4+ yields for monochloramine removal were derived from the slope of the linear regressions.

In the search for factors responsible for the different N2 yields, the elemental composition of the carbons was investigated and correlations with the N2-yield of the four carbons were calculated. Results are shown in the following table:

Carbon	N_2 yield in % [a]	Elemental analysis in g g_{GAC}^{-1}				Trace metal concentration in µg g_{GAC}^{-1}						
		C	N	H	S	Fe	Mn	Co	Ni	Cu	Rh	Pd
blank		n.d.	n.d.	n.d.	n.d.	8.3	0.05	n.d.	n.d.	0.4	n.d.	n.d.
K835	21.3±4.1	86.0±0.0	0.2±0.02	1.2±0.03	0.1±0.00	32±13	8.1±0.3	0.04±0.0	0.9±0.3	14.1±0.4	n.d.	0.004±0.001
100058	11.6±3.0	96.9±0.0	0.1±0.01	0.5±0.00	1.4±0.03	2483±349	47.5±11.5	1.1±3.5	74.8±0.0	10.9±2.7	n.d.	0.004±0.01
Centaur	4.2±3.0	81.5±4.1	0.7±0.14	1.4±0.03	0.8±0.01	172±50	2.5±0.9	2.2±0.3	9.4±2.9	10.2±2.0	n.d.	0.050±0.005
30N	0.5±4.7	84.6±0.3	0.3±0.00	0.8±0.02	0.4±0.01	4306±216	90.5±11.2	9.2±1.0	16.0±0.1	6.8±0.3	n.d.	0.083±0.007
r		0.32	0.55	0.03	0.26	-0.59	-0.55	-0.80	-0.02	0.95	-	-0.89
p-value		0.68	0.45	0.97	0.74	0.41	0.45	0.20	0.98	0.05	-	0.11

n.d. ... None detected

The content of trace metals found in the carbons investigated was typical for activated carbons prepared from natural raw products. It has been shown in past studies that metals such as Fe, Pd or Cu can favour monochloramine conversion to either NH4+ or N2. The positive correlation coefficient indicated that copper promotes monochloramine conversion to N2. Previous batch studies, that support our findings, showed that copper catalyses monochloramine decay by direct catalysis of Cu(II) and indirect catalysis. Results indicate that the copper content of the carbons significantly correlates with the observed N2 yield. This can be explained by direct catalysis of the disproportionation of monochloramine by Cu(II), producing dichloramine, which in turn is known to be completely degraded at the carbon surface to N2.

$$Cu^{2+} + NH_2Cl \rightarrow [Cu^{II}NH_2Cl]^{2+} \text{ (complex)} \tag{8}$$

$$[Cu^{II}NH_2Cl]^{2+} + NH_2Cl \rightarrow NHCl_2 + NH_3 + Cu^{2+} \tag{9}$$

Assuming the same process occurring in GACs, dichloramine will be further transformed at active carbon surface sites to N2. This two-stage process provides a feasible explanation for the monochloramine transformation to N2 found for GACs with a high Cu content. It has to be noted here that according to literature data, the copper content varies significantly among different batches of the Centaur carbon (24.16 µg g-1 GAC, 12.2±2.0 µg g-1 GAC in this study). Such differences might cause the different conversion of monochloramine to NH4+ observed between this study and results published previously.

Conclusions

Concludingly, the investigations showed that there is strong evidence that the yield of monochloramine conversion at activated carbon surfaces to molecular nitrogen increases with increasing copper content. A N2-yield as high as possible is desirable. Model calculations not shown here demonstrated that the decrease concentrations of monochloramine in the basin can be decreased by a factor of 2 to 3 by choosing the right GAC.

ORAL 37

MODELLING THE FORMATION AND DEGASSING OF CHLOROFORM IN SWIMMING POOL FACILITIES

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It has been widely published that the reactions between the disinfectants and the compounds introduced by swimmers (such as sweat, bacteria, skin particles and urine) generate trihalomethanes (THMs). The exposure to high level of THMs for long periods may present health risks to the swimmers. According to PWTAG, chlorine-based disinfectants mainly produce trichloromethane (chloroform), representing over three quarters of the total THMs [1]. To date, academic research in quantifying the rates of reaction or formation have been limited. A European research consortium for the Intellipool project has performed laboratory studies and collected pool measurements to estimate the rate of formation and degassing of chloroform in indoor swimming pools.

Aims
There are currently no real-time sensors for chloroform measurements in air. The Intellipool project aims to predict chloroform concentration in pool water and the subsequent degassing to the pool hall in indoor swimming pools. This will enable the management of, and possibly the reduction of, chloroform concentration in the air of the pool hall. Chloroform reduction will be facilitated by improved pool water treatments that take into account 3D flow fields in the pool water at diverse swimming pool operating conditions such as varying bather loads and pool activity levels.

Methods
The following hypothesises were tested:

- Dissolvable Organic Carbon (DOC) release rate per bather considering instantaneous, continuous and incidental release
- An average amount of citric acid content in DOC
- Citric acid as the main compound responsible for chloroform formation
- Chloroform formation kinetics from chlorine
- Effect of water treatment systems with various efficiencies.

The chemical kinetics information for the formation of chloroform was obtained from laboratory experiments. Samples of urine were measured for their initial Non-Purgeable Organic Carbon (NPOC) contents and then chlorinated; the concentration of the chloroform formed due to this reaction was then measured over time.
The degassing model was developed based on in-situ measurements, physical parameters and industrial guidelines. The minimum chloroform degassing rate by mass was based on measurements

of aqueous carbon dioxide concentration during a night period with no guests and no addition of potable water to the system. This baseline rate is then associated with different pool water temperatures, based on physical parameters such as the vapour pressure of chloroform and its concentration in aqueous phase. In addition, the effect of bather load and pool activities on increased disturbance of water surface resulting in increased rate of degassing were estimated based on industrial guidelines, and a mean mass transfer rate of chloroform obtained during the normal operation of the swimming pool. This was then generalised to account for the pool dimensions and 3D flow fields of water. The model was tested for various parameters (i.e. reaction rates, degassing rates and water recirculation rates), and the estimated chloroform concentration in water was compared with the measured values in the swimming pool. This validation measurement consisted of time histories of bather load, DOC, and chloroform concentrations in pool water.

Results

As a case study, the best mathematical models for chloroform formation and degassing are used to estimate the chloroform concentration in the water of a swimming pool with conventional water inlets and outflow channels. The results are compared with that of an improved design. The chloroform concentration in water and degassing rate of the improved design are then quantified for a bather load profile of 7 consecutive days assuming (i) degassing but no removal of chloroform in recirculated water, (ii) degassing and partial removal of chloroform in treated recirculated water, (iii) degassing and full removal of chloroform in treated recirculated water, by innovative pool water treatment techniques.

Conclusions

By better quantifying the formation rate of chloroform in water and the corresponding consumption rate of DOC, this allows the estimation of chloroform concentration in water at varying bather loads and pool activity levels. The impact of innovative pool water treatment techniques to minimise volatile disinfection by-products in water can be assessed. This will in turn achieve better indoor air quality and reduce energy consumption for supplying required fresh air.

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Session VI

Regulations

CHAIR: *Antonios Papadakis, Georgia Mandilara*

ORAL 38

DEVELOPING A LONG-TERM STRATEGY AND PUBLIC HEALTH SUPPORT SYSTEM FOR IMPROVING HEALTH AND SAFETY AT PUBLIC AQUATIC FACILITIES IN THE UNITED STATES

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Aims

The speaker will discuss the development and utility of creating a non-governmental organization to assist the U.S. Centers for Disease Control and Prevention (CDC) with keeping its Model Aquatic Health Code (MAHC; www.cdc.gov/mahc) up to date and relevant for public health and aquatic sector users in light of rapid aquatic sector innovations and emerging public health threats. Swimming is one of the most popular sporting and leisure activities in the United States, which boasts ~310,000 public aquatic facilities and >1 billion annual days of swimming. Unfortunately, in addition to health benefits associated with swimming, swimming can also result in preventable health and safety incidents, including drowning (~4,000 fatalities/year), pool chemical–associated injuries (3,000–5,000 emergency department visits/year), and waterborne disease outbreaks (650 of which have been reported to CDC for 1978–2012 and the annual incidence of which has significantly increased, particularly since the late 1990s). Deficits in facility operation frequently occur with data showing 11.8% of public pool and 15.1% of public hot tub/spa inspections resulting in immediate closure due to ≥1 imminent health hazards. This makes it critical that public aquatic facilities be designed, constructed, operated, maintained, and inspected to keep patrons and staff healthy and safe. In the United States, no federal regulatory agency is responsible for these facilities. As a result, most public aquatic facilities are regulated at the state or local level; 68% of local health departments regulate, inspect, or license them. The same state/local public health agencies individually devote substantial time and other resources to develop, review, and update their regulations, leading to considerable resource use and variation in codes across the United States. To address these public health issues, CDC developed and released the 2014 MAHC (1st Edition) in August 2014 after a 7-year multi-stakeholder effort by a consortium of public health, aquatics sector, and academic partners to develop the first all-encompassing, data-driven, national model guidance to improve health and safety. The adoption of key elements in the MAHC is anticipated to: 1) reduce injuries, illness, and associated costs; 2) reduce closures related to imminent health and safety hazards and code violations; 3) drive code standardization and adoption of minimum standards; 4) promote incorporation of science-based practices into environmental health aquatic programs; and 5) decrease resource expenditure to create and update codes at the state/local level. To enable regular MAHC updating, a new non-governmental, non-profit organization, the Council for the Model Aquatic Health Code (CMAHC; www.cmahc.org), was created to build a national network of public health, aquatics sector, academic, and other stakeholders to regularly advise CDC on needed updates and improvements to the MAHC. Partnering with the CMAHC is a critical feature of CDC's national plan to improve health and safety at public aquatic facilities.

Methods
The CMAHC was created as a national organization to fulfill a key recommendation from potential MAHC users: MAHC guidance must be regularly updated. Since the MAHC is not a regulatory document, its recommendations can only be made enforceable if state or local jurisdictions choose to adopt its recommendations. Feedback from stakeholders indicates adoption is dependent on the guidance being current, data based, and up to date. The update and improvement process was modeled on the system for regularly updating the model U.S. Food Code. The CMAHC was created in the context of strong partnerships, and a philosophy of "evolution, not revolution" since incremental, versus extreme, change should make it easier for state and local authorities to adopt or enact the guidance. To measure MAHC impact, track adoption, and yield data useful for updating the MAHC, CDC also implemented a new sentinel surveillance network to collect and analyze aquatic facility inspection data.

Results
The CMAHC was created in 2013 with a vision of "An up-to-date, knowledge-based MAHC that supports healthy and safe aquatic experiences for everyone and is used by pool programs across the U.S.". Since its creation, the CMAHC has named a Board of Directors, created an Executive Director position, and has a membership of >630 public health and aquatics sector representatives. The CMAHC has created processes for a) members to submit proposed MAHC change requests (CRs), b) a Technical Review Committee to review CRs and make member voting recommendations, c) members to comment on CRs throughout the review period, d) a biennial conference to facilitate member discussions of CR pros and cons, e) members to vote on each CR, and f) transmission of CMAHC CR voting results to CDC to consider during MAHC revision. In July 2016, the 2016 MAHC (2nd edition) was released, incorporating updates and improvements from 91% [84/92] of CRs passed by the CMAHC. Based on member feedback from the first biennial conference in 2015, the CMAHC update process is being improved prior to the 2017 conference. All, or portions of, the MAHC are beginning to be adopted in multiple jurisdictions. Other evidence of MAHC acceptance includes environmental health aquatic programs granting variances based on MAHC content, aquatic sector revision of operational materials to make them MAHC compliant, and growing acceptance of MAHC-specific design requirements.

Conclusions
The CMAHC has developed a robust process for gathering and assessing national input from public health and aquatics experts to aid CDC in regularly updating and improving the MAHC. The process facilitated CDC's revision of the MAHC and release of the 2016 MAHC (2nd Edition) in <2 years after the release of the 2014 MAHC (1st Edition). Partner feedback indicates the MAHC is beginning to be viewed as the standard of care in U.S. aquatics. The CMAHC process will enable CDC to regularly update and improve the MAHC. The CMAHC process is also building technical expertise and guidance on how to use and interpret the MAHC. Processes founded on discussion, inclusivity, and open communication, such as those used in the development of the MAHC and the CMAHC, have proven successful in building a public-private partnership to improve aquatic health and safety in a country without federal aquatics regulation, and consequently, where regulatory authority is non-uniform across state and local jurisdictions.

ORAL 39

A PROTOTYPE AND METHOD TO TEST MATERIALS AND TREATMENTS: A "CAVY" SWIMMING POOL

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Aims

The importance of hygiene surveillance in swimming pools has been clearly underlined by WHO guidelines[1]. Since no specific European legislation, related to swimming pools, SPA and similar environments, is available, several countries developed different regulations and surveillance strategies[2,3]. In Italy, the current regulation is presently under revision and several indicators are questioned or proposed de novo[4]. The identification of new parameters or their update is questioned based on scientific knowledge and guidelines, but how to test novel strategies or markers? If in clinics, established steps *in vitro* (e.g. tubes, plates) and *in vivo* on small animals (e.g. mice, guinea pig) are available to test and approve a new therapy, also pools require simple experimental models for exploratory tests that can mimic conditions and support decisions. New materials, sophisticated probes or innovative disinfection strategies evolve rapidly, and their comparison, validation and implementation require appropriate experimental models to simplify and diffuse the acquisition of preliminary data before they will be approved or extended on a large scale. Information obtained from in vitro, in vivo and real-world applications are essential. Several pilot models for pools were described but their transferability to everyday hygiene laboratories is limited by large dimensions, management complexity or difficulty in performing contamination experiments under safe conditions. Therefore, a scaled prototype was developed for evaluating materials and disinfectants, performing simulations of pathogen outbreaks or hygiene procedures under safe and controlled conditions. Its application to test biofilm formation of different materials in pools was tested.

Methods

Design, development and construction of a laboratory prototype to simulate critical points was performed in collaboration with the R&D departments of A&T Europe and MDD University Spin Off; setup of the steady state conditions and fluid dynamics evaluation; monitoring of parameters. Application to assess biofilm formation on pools materials under different disinfection conditions. Tested materials include: austenitic stainless steel AISI grade 304 2B finish (1), Glossy glazed porcelain tile (2), acrylonitrile butadiene styrene (3), reinforced plasticized poly-vinyl chloride (PVC-P) membrane (4), hard PVC Myrtha-technology hot rolled on stainless steel in two different coatings (5, 6). Simulated contaminations were performed with *Enterococcus faecalis* (ATCC 7080) and *Pseudomonas aeruginosa* (ATCC 9027). The bacteria were cultured at 37 °C (TSB) for 18 h, and the required concentration adjusted by dilution with the NaCl solution (0.9%), inoculated on the surface of different materials, exposed in the prototype and tested molecular methods.

Results

The prototype reached the steady state under different conditions, showing chemical, physical and fluid-dynamics stability (Fig. 1A). A method was optimized for testing materials (Fig. 1b), following a static approach based on inoculation/maturation of biofilm and a dynamic testing in the prototype. A molecular method was optimized to test biofilm formation by real time PCR monitoring of specific indicators or composite microflora. A tool for exposing materials at least in duplicate under identical fluid-dynamic conditions was developed and successfully applied. Tested materials showed different response to biofilm induction (Tab.1): PVC samples 4 and 6 displayed the strongest resistance to bacterial adhesion providing the best response to biofilm formation under different conditions. This approach seems promising and may open new perspectives for improving pool biosafety and pipeline maintenance.

Conclusions

Current advances in hygiene management of swimming pools innovate materials and water treatments as well as methods for surveillance and monitoring. However, their evaluation under critical conditions requires small scale models to perform laboratory simulations. Like clinical pharmacology used animal studies on Guinea Pigs or small animals we propose a kind of "cavy" swimming pool and a method for "in vivo" testing. Several materials were evaluated for biofilm formation, showing the effectiveness of the exposure approach and methodological protocol.

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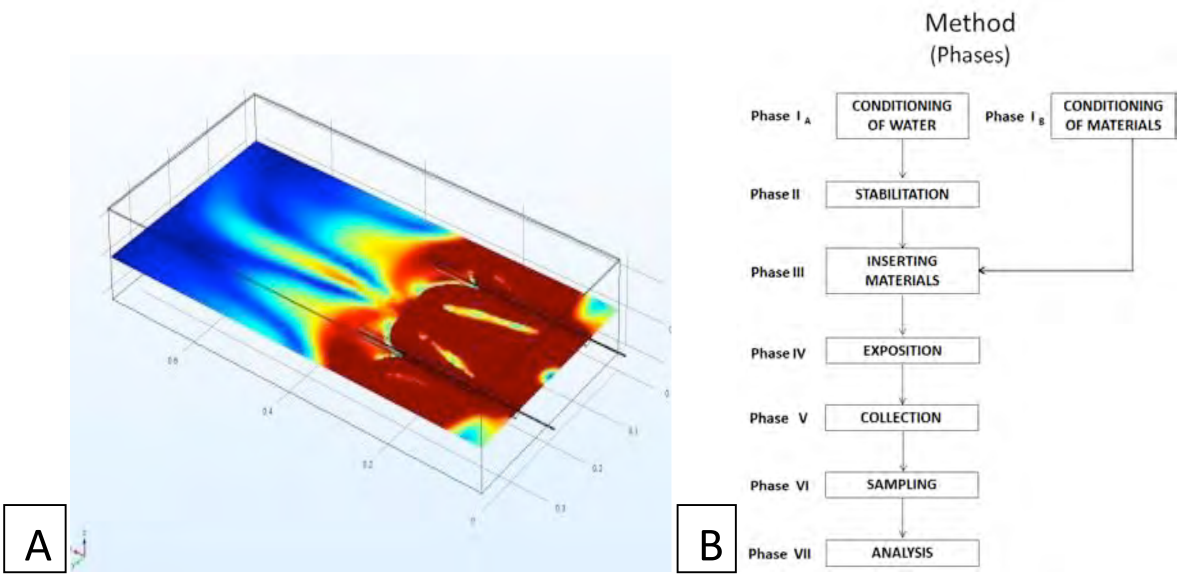

Figure 1. A) Simulation test of fluid dynamic; B) Flowchart summarizing the phases of the method for testing materials under different treatment conditions.

Table 1. Biofilm formation on several materials. Exemplificative raw data at different Chlorine levels. Molecular analysis of residual bacterial DNA measured in Cycle Threshold. *n.d: below detection limit

	Chlorine (0.7 ÷ 1.5 mg/l)		Chlorine (<0.7 mg/L)		Chlorine (<0.3 mg/L)	
Materials	Time 0 h (C_T)	Time 24h (C_T)	Time 0 h (C_T)	Time 24 h (C_T)	Time 0 h (C_T)	Time 24h (C_T)
1	25.12	38.665	23.09	26	23.09	24.20
2	19.04	38.47	21.23	28.9	21.13	23.03
3	21.9	35.33	22	21.59	22.2	19.81
4	20.93	n.d*	23.72	29	23.72	28.5
5	23.69	38.295	22	23	21.5	23.14
6	23.69	n.d*	21.03	25	21.03	27.64

ORAL 40

REVIEW OF THE NEW UK GUIDELINES FOR PREVENTING THE RISK OF INFECTION FROM SPA POOLS AND THEIR FUTURE DEVELOPMENT BY PWTAG

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Aims

Spa pools are self-contained bodies of warm (30-40°C), agitated water designed for sitting or lying in and not for swimming. The water is circulated through jets with or without air induction bubbles and can be sited indoors or outdoors. Spa pools are a recognised source of disease caused by infectious agents including *Legionella pneumophila,* the cause of Legionnaires' disease, *Pseudomonas aeruginosa* and non-tuberculous mycobacteria. They are the third most common cause of Legionnaires' disease in the UK. The first guidelines for spa pools were produced by SPATA in 1983 followed by national guidelines produced by the government funded PHLS in 1994. These were updated jointly by the PHLS and Health and Safety Executive in 2006. Since then there has been an increase in the variety and size of bespoke spa pools particularly for commercial use in public leisure facilities. New designs of factory built spa pools primarily designed for domestic use, now usually called hot tubs, including foam filled and inflatable pools have been introduced. Hot tubs are used for a wide range of applications some of which have significant inherent risks such as hiring out for use as birthing pools. Incidents of infection derived from spa pools, particularly hot tubs continued despite the earlier guidance and UK legal requirements for a risk assessment and the implementation of suitable control measures to prevent exposure to infection. In 2013 the general guidance on UK regulations for the prevention of Legionnaires' disease was updated (*Legionnaires' disease: The Control of legionella bacteria in water systems. Approved Code of Practice and guidance on regulations [L8,* 4th edition] http://www.hse.gov.uk/pubns/books/l8.htm).With the continuing incidents of infections, increased risks from the changes in design and use of spa pools and hot tubs and in the light of the update of L8 there was a need for tightened and updated guidance on the prevention of infection from spa pools and hot tubs with the aim of decreasing the incidence of such infections.

Methods

The guidelines were revised by a drafting committee composed of individuals with policy and technical expertise from the HSE, various public health and environmental health bodies from all parts of the UK, trade associations and learned societies including PWTAG. A draft was subjected to a process of external comment before publication in January 2017.

Results

The new guidance HSG 282 *The control of legionella and other infectious agents in spa pool systems* (http://www.hse.gov.uk/pubns/priced/hsg282.pdf) is freely available from the HSE. It consists of 62 pages in 5 sections: legislative requirements; types and settings; design and commissioning; operation and maintenance; testing and monitoring water quality. An appendix includes spa-pool checklists to assist risk assessments. The first section relates primarily to UK law but the remainder has worldwide relevance. Not only the operator has responsibility in controlling the risk. The importance is emphasized of designers, manufacturers, importers, suppliers including those who hire out devices and installers ensuring such pools are designed, constructed, tested, installed and commissioned so that they are safe and any risks are controlled when they are used. The document clearly defines and describes the types of spa pool dividing them into two groups. Bespoke spa pools which are those built *in situ* using standard, factory built parts and may be modified or added to on site. They generally have a higher bather load, are of a deck level overflow design with a balance tank and are used in commercial settings. Hot tubs are self-contained factory-built units and generally designed for a small number of people to sit in and do not have a balance tank. Hot tubs are sometimes also installed and used as part of a business activity for example in rental holiday homes, hiring for parties and even in cinemas! It is important to consider the future use of the spa pool in the design. The design bather load is a key characteristic. A domestic type hot tub should never be occupied by more than one person per seat and would not be suitable when there is a potential for a high bather load and there is continuous use. Features of the design that can reduce the risk of microbial growth are described including the choice of materials of construction, accessibility for maintenance and cleaning including pipework. During commissioning it is important to ensure the pool system is disinfected, and tests are carried out including chemical and bacteriological analysis and comprehensive functional water tests to provide evidence it is operating correctly. The section on operation and maintenance provides examples of typical frequencies for commercial and domestic type pools. There is also information of on different disinfectants that are available in addition to chlorine. Disinfectants other than chlorine must be independently shown to provide satisfactory chemical and microbiological water quality. The recommended frequencies of chemical and microbiological monitoring and the appropriate actions in response to the results are provided. Chemical tests should always be undertaken at the time of microbiological sampling to enable sensible interpretation of the results. Microbiological monitoring for aerobic colony count, *Pseudomonas aeruginosa, E. coli* and coliforms is recommend monthly and testing for *Legionella* quarterly.

Conclusions

This updated guidance provides some valuable clarification on the classification and uses of spa pools. It emphasizes the importance of the consideration and control of the bather and the type of use to which the pool will be put in formulating appropriate control strategies. In many respects it is not as practically useful a document as the guidance it replaces. It has no trouble shooting guide, is only available as a pdf and has a limited range of examples and no photographic examples of good and bad practice. It also is not designed for use by the purely domestic user for whom there is no good guidance. PWTAG in collaboration with others is planning to publish a printed version of the guidance to include more practical help and examples. In addition PWTAG plans a separate simpler document for domestic owners which are required since manufacturers' guidance is frequently woefully inadequate.

ORAL 41

UPDATING REVIEW ON ITALIAN SWIMMING POOL REGULATORY FRAMEWORK

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Aims

In 2003, the Italian Ministry of Health, with the technical support of the National Institute of Health, 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 2003 Agreement). In the last few years, several new products and technologies for water disinfection became commercially available, making current parameters and verifying activities obsolete. To date based on this rationale Italian Ministry of Health is going to provide a revision proposal on hygienic requirements for swimming pool construction, service and health surveillance in substitution of 2003 agreement's technical attachment, even to provide a clearer exposition about the way to accomplish overall duties.

Regulatory framework and updating activities

The 2003 Agreement was the first national legislative provision intended to protect public health providing an overall control of the water and facility areas. Previous acts issued in 1951 and especially in 1991 were poorly adopted because of the inadequate legal basis among the involved authorities. The new proposal will modify the 2003 Agreement. As a part of updating activities, besides new agreement proposal, the new European standards EN 16582:2015 and EN 16713:2016 have now entered into force in Italy, respectively on 14/10/2015 and 17/03/2016. As a result, the Italian standard UNI 10637:2015 has been revised and optimized in scope by the UNI WG11 involving several authoritative Italian experts (*e.g.* Assopiscine, etc.). In order to correctly harmonize standard requirements and current regulatory framework, UNI 10637 is assigned for all pools that can be classified as public, collective, of in apartment block and of a clinic or rehabilitation facilities, neither private nor domestic; on the other hand, UNI EN 16582 and UNI EN 16713 is specific for private or domestic pools.

Results and Conclusions

Supply water for pool, firstly forces to comply drinking water controls and their legislative requirements, and now needs local health authority's compliance, which has jurisdiction on external controls. Regarding the self-monitoring plans in swimming pools, the new proposal will redefines several issues. As the internal control process, self-monitoring assessment is the way to check the correct activity of the swimming pool facilities by pool manager. It is a procedure compiled on risk assessment structure and must include identification of potential risk, pool's itemized list, communication to the customers and employees, water quality monitoring, recording of the analytical controls results and detailed work instructions. Analytical methods for official controls are described in ISTISAN Report 13/46 and 07/31 both for microbiological parameters and for chemical parameters. About disinfection, the new agreement proposal introduces Regulation (UE) 528/2012

that separates two principal biocides application fields: a first one including disinfectants and algaecides not for direct use on human beings and animals (PT2) used also for swimming pools maintenance, and second one including drinking water disinfection (PT5). Overall, it can be used only chemical biocides both registered in positive list and provides by European review programme for existing active substances. CAS number inserted in table is an innovative feature, as requested by REACH Regulation. Among new disinfectants, regarding specific strict circumstances, it can be possible to apply sodium hypochlorite made by on-site brine electrolysis, bromine products, UV disinfection and dichloroisocyanurate and trichloroisocyanurate salts.
A new parameter, electrical conductivity, has been introduced. Acceptable value both for pool inlet water and for pool water is minor or equal 1,000 µS/cm in addition of supply water value. Coarse and fine solids parameters are deleted for pool inlet water, however coarse solids absence in pool water will be required. It is contemplates more strict isocyanuric acid levels both for pool inlet water and pool water wherever stabilized chorine is used. Disinfection by-products trihalomethanes will be a new parameter for pool water (100 µg/L). Free active chlorine parameter in pool inlet water will increase from 0,6 to 0,7 mg/l. Nitrate value and organic matter concentration for pool inlet water will not require drinking water concentration threshold, just respectively a value of ≤ 20 mg/L and from ≤ 2 to ≤ 4 mg/L of O_2 in addition of supply water parameter value. Main difference about microbiological requirement will be the complete elimination of the parameters for pool inlet water; just keep surveillance on its hygienic status by control self-monitoring procedure. Parameter value of *Staphylococcus aureus* will modified from ≤1 to ≤ 10 ufc/100 ml as recommended by WHO. 22°C bacterial count parameter will be eliminated because no longer needs as water quality indicator compared to 37°C colonies count parameter. Air temperature limit will be set on 26°C for swimming area and 24°C for others. If there will be an air-conditioning system, temperature will not exceed 28°C. Ventilation value for customer's area will be redefine at the maximum value of 0,20 m/s (estimation is required only in forced ventilation system), while air-exchange system will not has specific parameters value, just will satisfy standard UNI 10339 (recommended flow rate of $2.5\cdot(10^{-3}\cdot m^3/s\cdot m^2)$. For determination of echo decay time, it will set parameter value on 2.5 s for pool currently working and 1.8 s for new buildings. Among acoustic requirements it will be introduced a noise evaluation index that can't exceed 75 dB. There is also a specific law act providing acoustic requirements for sound systems. The revision proposal on swimming pool agreement between state and regional authorities made by Ministry of Health and supported by the Italian Institute of Health, it was necessary as technology and knowledge growing, in order to harmonize health surveillance protocols and costs reduction. Regulation updating pathway can provides pool water control procedures optimization, even for pool inlet water in addition of a control self-monitoring procedure. Before the meeting between government and regional authorities, the Ministry of Health started a 30 days public consultation on the new agreement framework. Participants were 176, 95% of them declared they knew current legislation. Remarks were about thermohygrometric requirements (66 %), microbiological (69%) and chemical (49%) requirements. The public consultation ended 30th of June 2016.

ORAL 42

THE EU BIOCIDAL PRODUCT REGULATION 528/2012 AND THE IN SITU GENERATION OF ACTIVE SUBSTANCES

Reuß A

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For decades, disinfecting agents have been used to guarantee the hygiene of swimming pool and bathing water, with this also required by national infection protection laws. These agents are primarily chlorine products but also include ozone or bromine, as well as combinations of these. As the disinfection process generally includes killing living material and in doing so deploys a killing (biocidal) effect, the disinfectants used are therefore biocides. As such, they are subject to the EU Biocidal Products Regulation 528/2012 (BPR) and require approval and authorization as active substances or biocidal products as of 1 September 2013. Being in place non-bindingly since 1998 (BP Directive), following the BPR, approval and authorization is now a binding European law. The new regulation is not only intended for ready-made disinfectants, but also for active substances produced on site, known as in situ generated substances, as well as their precursor substances. Thus, the regulation has resulted in significant changes for the market availability and the use of disinfectants in the EU, as this included the extention of the definition of a biocidal product and the regulatory framework of the biocidal law, so that disinfectants that were previously barely or not at all affected are now subject to the BPR.

Background
The biocide legislation was managed uniformly for the first time by the single market regularization Biocidal Products Directive 98/8/EG. This Directive initially aimed at dismantling trade barriers and preventing dangerous implications of biocides, but it largely depended on voluntary implementation in countries where the directive was not converted into national law. In September 2013, the BPD was replaced by the BPR, which means that it is immediately applicable law throughout the EU and in countries associated with the EU. The extent of the BPR covers more than the BPD. Not only is the introduction of biocidal products onto the market controlled by the new BPR, but also explicitly their use. Here, use is defined as "*all measures implemented with a biocidal product including storage, handling, mixing and applying, excluding measures that occur for the purpose of exportation of the biocidal product or the goods treated out of the Union.*"

Aims
The aim of the new BPR is to guarantee the protection of people and animals' health as well as the environment at a high level as well as to ensure that the permitted biocidal products are sufficiently effective for their respective areas of use and that they do not have any unacceptable effects.

On site production of disinfectants and advantages
During in situ production, disinfectants are generated in small quantities when needed via a chemical reaction just *before* or during use *on* site, either with or without precursor substances (precursors) and/or equipment at the place of use.

With the BPR, according to the wording of the EU Biocide Regulation, several hundred thousand users and consumers of systems ranging from commercial water treatment systems to private households which now count as generators of biocides.
Independent of the procedure used, producing disinfectants with in situ systems has the benefit of avoiding transport, storage and handling of the hazardous substances, as well as the advantage of producing the biocide on site and in the necessary concentration for immediate *usage*. In situ generation make up a significant part of replacing hazardous compounds, primarily with regards to labour protection and operational safety. Also disinfection-by products, e.g. chlorate, may be minimized. As a result, in situ generation has been established as an effective and safe alternative to using centrally generated biocides in water treatment.

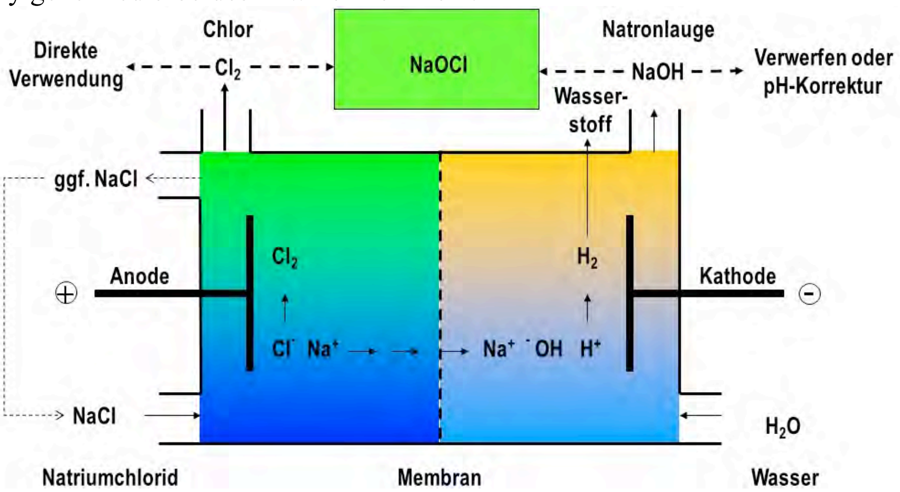

Figure 1: Example of in situ generated active chlorine by means of electrolysis of sodium chloride (*Dygutsch, Beutel, Reuß*, AB Archiv des Badewesens 07/2013)

Implementation of the Biocide Regulation

The process of obtaining authorization for disinfectants provided in the BPR consists of two stages. First, the active substance contained and to be used (e.g. chlorine) must be approved, then the biocidal product containing the active substance (e.g. calcium hypochlorite) must be authorized. For this, extensive files must be submitted to the appropriate authorities with information including effectiveness, possible human and environmental toxicological implications and production procedures. Depending on whether classic chemicals or biocides produced in situ are concerned, the regulatory text is directed towards different target readerships. With classic chemicals made available on the market as biocidal products, the manufacturer/supplier must authorize the biocidal product. With in situ generation of biocides, the operator is legally responsible as the user and must observe the BPR. This can in practice not be performed by the operator on organisatory, administrative and primarily economic grounds. Therefore, the system producers or the suppliers of the precursors are actually responsible, even if they are legally not affected by the regulation.

Transitional Regulations

With old active substances, which came onto the market before 14/05/2000, the transitional periods according to article 89 ff. of the BPR apply. Products based on new substances may only be made available on the market and used after gaining authorization. For old substances which did not count as biocides according to the definition in the Biocide Directive 98/8/EG, but are now defined as biocides according to the BPR (e.g. ozone), article 93 applies. Old substances that already counted as biocides according to the old Biocide Directive (e.g. chlorine) shall be evaluated according to article 95 of the BPR.

Summary
The EU Biocide Regulation 528/2012 is a very complex piece of legislation that SMEs will find very difficult to understand or carry out. Most companies in the field of swimming pools are SMEs, the economic challenges thus only be overcome within a consortium with a corresponding sharing of costs. Since 01/09/2015, salt is permitted for use in electrolysis devices for producing chlorine on site solely by suppliers that appear on the article 95 list, either individually themselves or through their sub-suppliers. Operators must find out from their suppliers whether they or one of their sub-suppliers are listed under article 95, and only then can their operation of the in situ system be legally sound. Presently, no active substance has been approved and no biocidal product has been authorized, but all substances and products whose suppliers appear on the article 95 list can legally be used.

ORAL 43

ASSESSMENT OF SWIMMING POOLS IN THE LIGHT OF NEW POOL AND SPA REGULATIONS IN GREECE

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Aims

In the occasion of the 2004 Olympic Games in Athens, the Department of Environmental Microbiology of the National School of Public Health has inaugurated the 'SWIMMING POOL 2004' scheme. The purpose of the program was the assessment of the water's microbiological quality of the swimming pools in the Athens area on behalf of the pools managements, as a primary - self control. The pools were assessed according to the requirements of the current Greek regulation issued in 1973, which does not include *P. aeruginosa* in the microbiological parameters. The swimming pool legislations in the EU countries are extremely diverse due to the different approaches of the national health authorities, attributable to varying social, economic and cultural conditions. Many European countries (WHO guidelines included), follow more strict threshold values for total coliforms and heterotrophic microorganisms than the Greek regulation and consider *Pseudomonas aeruginosa* as a valuable criterion for the water's microbiological quality. For this reason we provided our clients with *P. aeruginosa* counts, even though they were not taken into consideration for the official pool assessment. The aim of the present study was to assess the pools of the 'SWIMMING POOL 2004' program for the last 12 years according to a) the current Greek regulation and b) the regulations applied in other EU countries.

Methods

The metadata from 2004-2016 was carried out extracting information for the participating pools assessment from the lab database, considering three microbiological parameters [Total Heterotrophic Plate Count (THC); Total coliforms (TC)*; Pseudomonas aeruginosa (Pae)*]. The microbiological tests were performed according to standard methods (ISO 6222 for THC, ISO 9308-1 for TC and *E. coli* and ISO 16266 for *Pae*). The data initially were assessed according to the current Greek legislation (1st scheme) where the recommended upper acceptable limits are: THC < 200 cfu/ml, Total coliforms < 15 cfu/100ml and *E. coli* < 1 cfu/100ml, and then according to the following limits (2nd scheme): THC < 100 cfus/ml, [a]TC < 5 cfus/100ml, [b]TC not detectable cfus/100ml and absence of *Pae*/100ml, based on the current regulation of various other countries. Basic statistical analysis was performed in order to assess the number of samples that were characterized as unsuitable for use according to both legislative approaches. Each result was evaluated as a value and not as a sample.

Results

Table 1 illustrates the results of our study. During the 12 year operation of the program a total of 11145 values were recovered for each parameter tested. For TC 1.7% and 2.1%[a] (2.4%[b]) of the total values were unacceptable according to 1^{st} and 2^{nd} scheme (a & b) respectively; that means that 0.4%[a] (0.7%[b]) of the TC values conforming the Greek legislation would be defined as “unacceptable” if more strict limits were applied. For THC 2.9% and 6.3% of the total values were not acceptable according to 1^{st} and 2^{nd} scheme respectively; thus, 3.3% of the THC values that met the Greek legislation requirements would be characterized “unacceptable” according to 2^{nd} scheme‘s microbiological standards. As far as *Pae* parameter concerns, Greek legislation does not include it as an indicator of the microbiological quality of swimming pool water, howevere 2.8% of total values (308/111145) would be characterized as not conforming the threshold of 0 cfus/100 ml; of these, 20% (62/308) were recovered from rehabilitation swimming pools.

CONCLUSIONS

According to our results, the microbiological limit set by the Greek legislation for total coliforms (< 15 cfus/100ml) is reliable enough in order to illustrate the microbiological quality of the pool water, since 0.7% of the total values only would be “unacceptable” in case of stricter limits (not detectable /100ml, 2nd scheme[b]). For total heterotrophic counts, 3.3% of the values would be additionally (of the 2.9% unacceptable according to the Greek legislation) characterized as exceeding the stricter limits of <100 cfus/ml; even though THC are not an indicator of water safety but mostly an indicator of the microbiological stability of the water and of the disinfection process effectiveness, , the limit set by the Greek legislation (<200 cfus/ml) should be reconsidered in order to ensure safe water. As far as *Pseudomonas aeruginosa* concerns, an indicator not included in the Greek legislation, 2.8% of the total values would be characterized “unacceptable” according to the limit of 0 cfu/100ml; taking into consideration the fact that *P. aeruginosa* is an opportunistic pathogen, which tends to accumulate in biofilms, and can represent a significant public health threat, mainly for vulnerable population (e.g. in rehabilitation centers), we believe that it should be included in the Greek legislation in order to attain the best swimming pool water quality. Considering the fact that Greece is a country with a heavy tourist industry and that it is visited by about 25 million tourists annually, who mainly use the hotel accommodation, quality of pool and spa water is one of the important issues for public health, concerning both guests and the domestic population.

Table 1: The percentages (numbers) of values exceeding themicrobiological parameters limits according to the 1^{st} scheme (set by the Greek legislation), of the 2^{nd} scheme (more strict limits, on the basis of other countries regulations) and between the two schemes. THC: *Total Heterotrophic Plate Count;* TC*: Total colifroms; Pae: Pseudomonas aeruginosa*

year	Total values /year	THC (>100 cfus/ml) 2^{nd} scheme	THC (>200 cfus/ml) 1^{st} scheme	100 cfus/ml <THC <200 cfus/ml	TC not detectable/100ml 2^{nd} scheme[b]	TC>5cfus/100ml 2^{nd} scheme[a]	TC >15 cfus/100ml 1^{st} scheme	not detectable <THC <15cfus/ml	Pae (>0 cfus/100ml) 2^{nd} scheme
2004	707	6.8% (48)	3.1% (22)	3.7%(26)	1.6%(11)	1.3% (8)	0.8%(6)	0.3%(2)	5.5% (39)
2005	874	9.6% (84)	5.2%(45)	4.5%(39)	1.7% (15)	0.5% (5)	0.35%(3)	0.22%(2)	3.2% (28)
2006	946	10% (94)	4.5%(43)	5.4%(51)	1.4%(13)	0.6% (6)	0.32%(3)	0.32%(3)	1.4% (13)
2007	1107	7.2% (80)	2%(22)	5.23%(58)	1%(11)	0.5% (6)	0.45%(5)	0.09%(1)	1% (12)
2008	1069	8.6% (92)	3.36%(36)	5.23%(56)	0.8%(9)	0.7% (7)	0.56%(6)	0.09%(1)	2% (22)
2009	1132	9.9% (112)	4.85%(55)	5%(57)	0.4%(4)	0.3% (3)	0.3% (3/)	0	1.3% (14)
2010	1112	7% (80)	3.6%(40)	3.6%(40)	0.7%(8)	0.5% (6)	0.35%(4)	0.18%(2)	0%
2011	978	3.5% (35)	1.95%(19)	1.65%(16)	2%(20)	2% (19)	1.7%(17)	0.2%(2)	0.4% (4)
2012	840	2.5% (21)	1.2%(10)	1.3%(11)	2.1%(18)	2% (17)	1.55%(13)	0.5%(4/)	1.6% (14)
2013	693	2.3% (16)	1.7%(12)	0.6%(4)	2.5%(17)	1.9% (13)	1.3%(9)	0.6%(4)	1% (7)
2014	577	3.5% (20)	1.9%(11)	1.55%(9)	13.7%(79)	13.7% (79)	11.6%(67)	2%(12)	1.5% (9)
2015	618	2% (13)	0.65%(4)	1.45%(9)	9.4%(58)	9.4% (58)	7.6%(47)	1.8%(11)	12% (74)
2016	492	1% (5)	1% (5)	0	1.8%(9)	2% (9)	2% (9)	0	15.5% (71)
Total/mean	11145	6.3%	2.9%	3.3%	2.4%	2.1%	1.7%	0.4%	2.8%

ORAL 44

UK POOL GUIDANCE - 33 YEARS OF KEEPING IT UP-TO-DATE

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PWTAG. UK

Since 1984 the Pool Water Treatment Advisory Group (PWTAG) has taken on the responsibility, as an independent organisation, for formulating authoritative guidance on the water treatment of swimming and spa pools in the UK. Historically PWTAG had support from government and other statutory bodies, but increasingly we explored other means of funding streams and secured a structure that will ensure its survival in the 21st century. This has involved setting up a dedicated administrative function and widening membership in and attempt to bring in a greater range of knowledge and youth. We have also established specific forums to exchange technical expertise and support with trade and industry.

All this is backed by the influence and income derived from the publication of PWTAG's authoritative book, *Swimming Pool Water: treatment and quality standards for pools and spas.* First published in 1999, and updated in 2009, this uniquely influential publication has sold over 11,000 copies.

This paper details the new structural arrangements and benefits of membership. It also considers our new *Code of Practice* and the new edition of *Swimming Pool Water*, due in July. It explains how the *Code of Practice* is being included in the latest UK Health and Safety legislation. It discusses the UK's major changes in policy which include:

- Filtration methods and standards
- Pumps and energy saving – highlighting significant cost saving
- Disinfection, why we set the standards we do
- *Cryptosporidium* – our current position, research projects and how our advice is changing
- UV standards and the impact on UK pools – the need for third party accreditation.

It also explains how *Swimming Pool Water*, the *Code of Practice* and our new training, qualification and accreditation system, *Poolmark*, are integrated and work together to improve standards. The valuable free advice – Technical notes, reference papers etc – on the PWTAG website will also be highlighted.

Session VII

POOL and SPA open discussion: WHERE ARE WE HEADING TO?

CHAIR: *Vincenzo R. Spica., Christiane Höller*

KEY SPEECH 6

WHERE ARE WE HEADING TO?

Höller C

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There is no doubt that swimming is beneficial for the health of people. It may be regarded by some as an unnecessary luxury, considering that other forms of exercise also promote well-being. However, it is crucial that everybody, especially children, learns to swim as early as possible in life. Therefore it is important to build community pools and pools in schools or to keep them at least in good working order and to minimize possible health risks. These can be caused for example by chemicals, microorganisms, technical equipment, management deficiencies or missing regulations. Although it might seem that the risks are already well-known recent developments give cause for concern.
In order to prevent infections swimming pool water is disinfected, usually with chlorine. During the last years chlorinated disinfection by-products (DBP) have been examined intensively, but other compounds may be important, too. New DBPs or DBPs which have not been considered yet appropriately have to be taken into consideration. Changing consumer demands like relaxing in brine or other salt containing waters may enhance the problem. For instance, using bromide as a disinfectant or disinfecting waters containing bromides may produce bromoforms; the impact of their toxicology has to be evaluated accordingly.
New pathogenic microorganisms are detected very rarely, but existing ones may change their properties and may suddenly become important in infection control. The increasing threat by antibiotic resistant bacteria is no longer limited to the hospital environment, but has reached the "normal" citizens in most countries leading to questions how to deal with this issue. And if we think about these potential pathogens we should also reevaluate our indicator organisms, because these are possibly not sufficient to predict modern health risks.
Not only disinfectants and microorganisms may change in their importance for pool users and pool owners. New technologies that are introduced into the market in one country may suddenly be promoted in another country, too. Common market, international standardization and regulations may make it impossible for a country to prohibit a certain development. On the other hand, positive experiences should be shared in order to enhance the availability of safe swimming pools.

ORAL 45

ACUTE OTITIS EXTERNA, A WATERBORNE INFECTION COMMONLY TRANSMITTED THROUGH POOL & SPA ACTIVITIES – A REVIEW

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Summary
Acute otitis externa (AOE), a quite common infection of the external auditory canal in children and adults, is associated very often with bathing (swimming-entertainment-sports) in swimming pools, especially during summer months. An important factor is the increase of water temperature leading to the evaporation of unstable disinfectants, and the increase of the number of swimmers. The concentration of pollutants in the pool deriving from the swimmers, such as hair, sweat, nails, carrying pathogens, is another important contributing factor. 80,5% of OAE cases occurred in summer (Roland και Stroman, 2002).
The most common microorganism that is responsible for these infections is *P. aeruginosa.* Information on the infectious dose causing AOE is inconsistent and incomplete, in contrast to other water-borne infections. The factors that contribute to the creation of this infection, and need to be considered, are many such as the microbiological quality of water, exposure time, and the structure of the external auditory canal, the creation of biofilm, environmental factors and endogenous or exogenous origin of *Pseudomonas aeruginosa*. The use of newer data will lead to the creation of algorithms that will help us approach the possible infectious dose and as result prevention of AOE by *P. aeruginosa* of waterborne origin.

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ORAL 46

SWIMMING POOL & SPA – OVERVIEW OF THE BENEFITS OF WATER TREATMENT AND APPLICATIONS FOR THE HUMAN MUSCULOSKELETAL SYSTEM

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Aims
The purpose of this contribution is to point on the importance of the medium water, for example in swimming pools, for the human health with emphasis on the musculoskeletal system and to give an overview of the different use of water and its physical effects. The healing effects of water have been known for more than 2,500 years.

Methods
Literature review.

Results
Water and its physical characteristics
Water is the only chemical compound that can be present in 3 aggregates (fluid as water, solid as ice, gaseous as steam).Consisting of the elements hydrogen and oxygen, as well as dissolved parts of salts, gases and organic compounds,water has special physical characteristics concerning density, buoyancy, movement resistance, hydrostatic pressure and thermal conductivity, heat capacity, as well as surface tension.
Water and human being - The history of water use
From the first settled people to the high cultures of antiquity over the Middle Ages until the modern age, there was always a conflict between an excess and an insufficient amount of water;floods or droughtthreatening life and property of the people. Impressive are all the water facilities, already constructed by our ancestors, characterized by creativity and innovation, in order to meet all requirements of use and to guarantee water to every human being. Water law was one of the first legal forms of co-founding the first civilizations. The great importance of the water is reflected in the philosophies of the earliest philosophers, who counted the water to the four primary elements. Thales of Miletus interpreted water as the primary substance of all being. Water belongs to the four-element doctrine introduced by Empedocles, and then represented by Aristotle (besides fire, air, and earth). Water also is represented in the Taoist five-element doctrine (besides wood, fire, earth, metal).
Water is of central importance in the mythologies and religions of most cultures. In many ancient religions, waters were universally and as springs honored as a sanctuary and as power and energy sources. The old term “water of life” is well known. According to old mythologies the unborn

children were concealed in springs, wells, or ponds, from which they were collected by the midwives. In Christianity, baptism is carried out by submerging the whole bodyin water or overflowing with water. In the Catholic Church, the Orthodox Churches and the Anglican Church blessing with holy water plays a special role.

Water and human health

70 % of the human body consists of water. So the intake of water is elementary necessary for the human's survival.Enriched with minerals, vitamins and calories, water can act as healing water, also with immune modeling effects.

Research has shown, that the external use of water, because of itsphysical characteristics, is an optimal medium for the treatment or prevention of diseases of the human body by the following aspects: Training and improvement of physical endurance, overall functional and muscular strength, flexibility and (joint) mobility, range of motion of joints, as well as physical and mental wellbeing and psychomotor balance,improvement of breathing, core stability, posture and gait, coordination, physical awareness and fitness and balance usingfor example muscle and psyche relaxing effects, maximum joint comfort, fun, relieved breathing.

To achieve these positive effectson the entire human body, physically and psychologically, water can be used in different ways and forms according to its 3 aggregates.

Because of the upward buoyant force of the water, indicated by the Archimedes' principle, the body which is immersed in the water is only 10% of its body weight, and the cardiopulmonary system, joints and spine are relieved and less stressed.

According to the study of Adjett et al. (2016) aquatic exercises are feasible for people with heart failure and support to maintain general strength, endurance and balance with emphasis on the cardiopulmonary system.Activities or movements in the water do not have to be swimming. It can be the simple non-specific movement like 'walking through the water'. In the treatment of diseases of the musculoskeletal system, especially back pain and joint diseases, for example due to degenerative changes or rheumatism, the use of water (hydrotherapy/balneotherapy) in any form or at any temperature (steam, liquid, ice) and aquatic exercises andspecific water gymnastics play an important role. Results of studies, e.g.Escalante et al. (1998), emphasize the positive effect of water on aiding normal gait and reducing joint pain by anti-inflammatory effects and gentle training of the joint-stabilizing muscles.

Conclusions

Movement in shallow and deep water in the swimming pool is the ideal, gentle or sportiveactivity for everyone regardless of age, physical constitution (weight, height), fitness and health condition / morbidity (with few exceptions) and promotes physical and mental health (curative-therapeutic and preventive) as well as psychosocial life.

ORAL 47

I SPY, I SPY WITH MY LITTLE EYE

A research about the effect of watching eyes on pre-swim shower behaviour

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Aims

The basis of this study lies in hygiene of swimming pools, where it is argued that taking a pre-swim shower would lead to a decrease in release of pollutants in the swimming pool, which in the end would lead to the decrease of health issues as red eyes and asthma. However, previous research has shown that not even half of the swimming pool visitors takes a pre-swim shower. Therefore, interventions are needed to increase pre-swim shower behaviour. Whereas previous research focused on 'conscious' behavioural interventions, this research focuses on 'unconscious' behavioural interventions, by using watching eyes. Watching eyes create an unconscious feeling of being watched, which lead people to behave in a prosocial way (for example: people litter less). It is argued that when swimming pool visitors are 'confronted' with watching eyes, they are more likely to take a pre-swim shower. So, this study aimed to increase pre-swim shower behaviour in swimming pools by using watching eyes.

Methods

Three interventions were designed, either containing watching eyes, a symbol, or a combination of both (see figure 1). This led to three conditions: eyes-only (no symbol), eyes + symbol, and symbol-only(no eyes). A fourth condition was added in which nothing was displayed (no eyes/no symbol): the control condition. Three methods were used to gather data for this study: observations, questionnaires and water quality measurements. Observations were used to monitor actual pre-swim shower behaviour, and the influence of factors as gender, age, carrying belongings, other people showering, et cetera. These factors were found to influence pre-swim shower behaviour in previous research. Questionnaires were used to monitor hygiene perceptions, importance of hygiene, and hygienic behaviour, and about the awareness and understanding of the interventions. It was expected that data about the factors mentioned before could give more insights about how swimming pool visitors feel about hygiene in swimming pools, and about the influence of the interventions. Finally, water quality measurements were used to monitor the release of pollutants in the swimming pool.

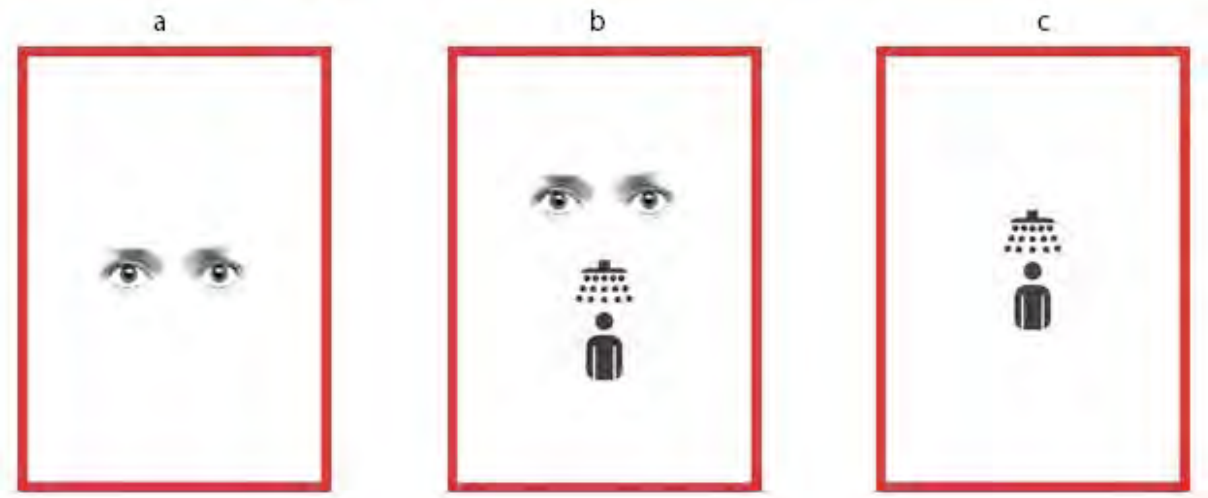

Figure 1: Interventions: Eyes-only (a), Eyes + symbol (b), and Symbol-only (c)

Results

The results provide evidence for the effect of watching eyes on pre-swim shower behaviour. It was observed that actual pre-swim shower behaviour increases during all three interventions, with the 'symbol-only' intervention being the most effective intervention. Furthermore, it was shown that perceptions of hygiene and hygienic behaviour were rated highest in the 'watching eyes + symbol intervention'. Finally, less pollutants were released during all three interventions, with the watching eyes + symbol intervention being the most effective intervention. The general results are shown in Table 1.

Table 1 – General results of all 3 methods and all 3 interventions and the control.

Method	Control	Eyes-only	Eyes + symbol	Symbol-only
Observations	35.3 %	45.3 %	45.3 %	49.4 %
Questionnaires	78.6 %	74.2 %	73.3 %	80.0 %
TN release from measurements (mg N /L per bather)	1.27	0.56	0.30	0.40

Conclusions

These results indicate that the watching eyes + symbol intervention is the best intervention to increase pre-swim shower behaviour. It is therefore recommended to use this intervention in swimming pools. This research has shown the effectiveness of watching eyes in a new context: in a swimming pool context. Furthermore, this research contributes to the body of literature about the influence of watching eyes on hygienic behaviour. Future research should specifically focus on fine tuning of watching eyes interventions to increase pre-swim shower behaviour, and in general on the underlying process between watching eyes and prosocial behaviour.

ORAL 48

DO HYGIENIC RULES AND WATER QUALITY REQUIREMENTS IN SWIMMING POOLS PREVENT DISEASE OUTBREAKS?

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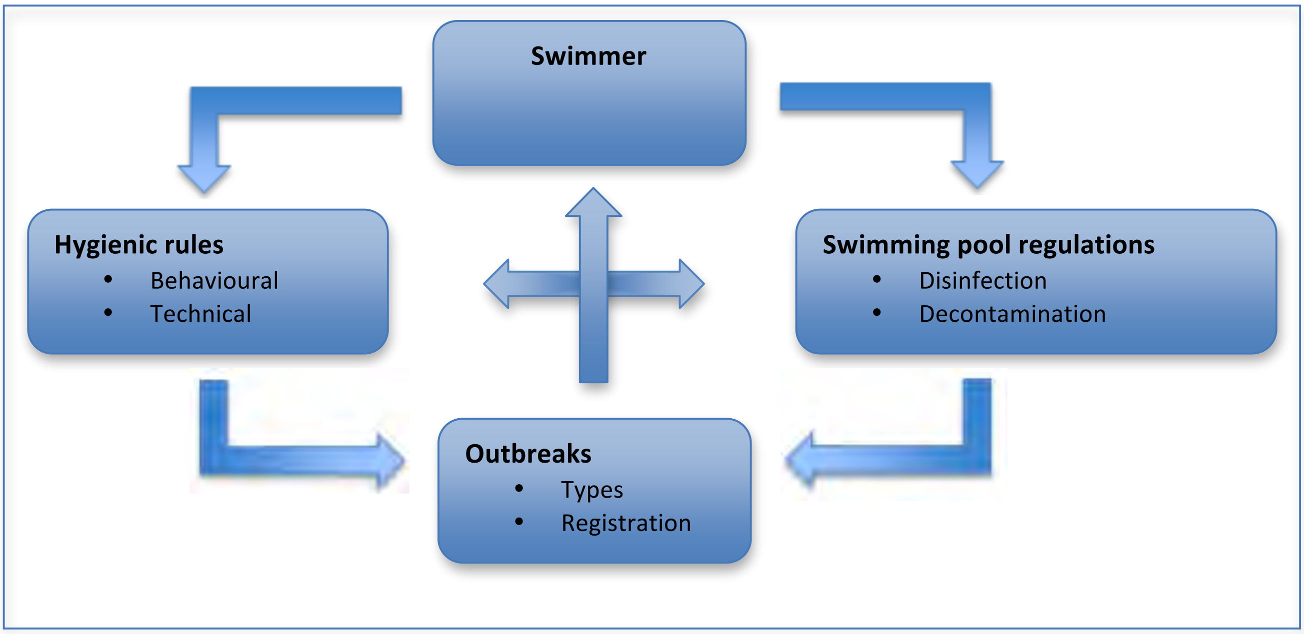
Aims
Firstly, the aim is to identify behavioural hygienic rules meant to affect swimmers' hygienic behaviour in swimming pools and their occurrence in guidelines and regulations in the European Union (EU). Secondly, to assess the evidence of the effectiveness of hygienic rules and water quality guidelines in preventing swimming pool-related disease outbreaks. Figure 1 visualises the parameters involved in hygienic swimming.

Figure 1: A diagram of parameters involved in hygienic swimming.



Methods
A comprehensive systematic literature review was performed to identify behavioural hygienic rules and hygienic water quality requirements for swimming pools that could prevent or reduce the number of disease outbreaks through swimming in swimming pools. To assess the evidence of the effectiveness of these hygienic rules and requirements in actually preventing swimming pool-related

disease outbreaks, EU member states were requested to provide information on national guidelines and regulations and national data on swimming pool-related disease outbreak.

Literature review
For inclusion in the literature review, four major categories of swimming pool-related health conditions were identified: ear infections, eye infections, skin infections and gastro-intestinal infections. Electronic databases including PubMed and Embase were searched using a set of relevant keywords. For every eligible study, the reference list was checked and useful references were added to the selection. Two independent data extractors screened selected papers, titles and abstracts; the full text was obtained when the content was deemed potentially relevant after a consensus procedure. The STROBE, AGREE II and AMSTAR instrument were used to assess the reporting quality of all studies, guidelines and systematic reviews, respectively.

Survey on guidelines, regulations and outbreak data
A request was sent to EU member states asking them to provide information about hygienic rules, water quality requirements in national guidelines and regulations for swimming pools, compliance with these rules and requirements, and on swimming pool-related disease outbreaks.

Results
From the literature review, fourteen hygienic rules were identified that are widely used, and could possibly reduce swimming pool-related disease outbreaks. Eight of these fourteen hygienic rules can reduce anthropogenic pollutant release into the swimming pool, or serve as personal health-preventive measure. Anthropogenic pollutants are brought into the swimming pool by swimmers, and can be initial, continual or incidental. Initial anthropogenic pollutants are released in the first minutes when the swimmer is in the water and consist of microorganisms remains of evaporated sweat, skin lipids, dirt, suntan oil and cosmetics on the swimmer's skin. Initial anthropogenic pollutant release can be reduced by taking a pre-swim shower, wearing a swimming cap, wearing flip-flops, cleaning of swimming aids, and using a pre-swim footbath. Continual anthropogenic pollutants are released during swimming activities and consist of sweat, skin cells and skin lipids. No hygienic rules were identified that could reduce continual anthropogenic pollutant release. Incidental anthropogenic pollutants are urine, vomit, faeces, spilled drinks or food. Incidental anthropogenic pollutant release can be reduced by taking a restroom break every 60 minutes, not swimming when ill (particularly with gastro-enteritis), and making sure young children wear a swim diaper. Personal health preventive measures are wearing a swim cap, using earplugs, wearing swim goggles, wearing flip-flops, cleaning of swimming aids, and avoiding ingestion of pool water (Table 1). From the survey, a response was obtained from 16 (57%) EU member states. The provided information contained technical features for disinfection and biological parameters needed for water quality requirements, such as pH-level (6.9-8.0), chlorine level (0.3-3.0 mg/L), bromide level (0.4-5.0 mg/L), maximum disinfection by-products levels (multiple groups and ranges), maximum temperature (33-40 °C), use of coagulants, recirculation time (6-8 h) and types of filtration systems. No information was provided on hygienic rules in national regulations or compliance to these regulations. Likewise, no data on swimming pool-related disease outbreaks was provided.

Conclusions
Behavioural hygienic rules can reduce anthropogenic pollution of swimming pool water, and can provide personal health protection due to prevention of infections, and could thus prevent swimming pool-related disease outbreaks. However, currently no studies have provided evidence that fewer swimming pool-related disease outbreaks occur as a consequence of fewer anthropogenic pollutants in swimming pools. The interviewed EU member states did not report extensive information on water quality guidelines and regulations, the implementation of behavioural hygienic rules, and the number of swimming pool-related disease outbreaks in their countries. From the obtained data it seems plausible that EU member states follow a guideline for water quality, such as the World Health Organization (WHO) guidelines for safe recreational water. National registration systems for data on

swimming pool-related disease outbreaks do not seem to exist in EU member states. Therefore, it was not possible to validate the effectiveness of such guidelines, hygienic rules and regulations in preventing swimming pool-related disease outbreaks.
In order to draft evidence based swimming pool regulations for EU member states, aimed at minimizing the number of swimming pool disease outbreaks, data on water quality parameters, guidelines and regulations, and disease outbreaks related to swimming pools should be registered. Therefore, it is recommended that EU member states do this individually and that umbrella organisations such as WHO or European Centre for Disease Prevention and Control facilitate the collection and analysis of data at a supra-national level.

Table 1: Hygienic rules and effect on anthropogenic pollutants, personal preventive health measure or swimming-related infection.

Hygienic rules	Anthropogenic pollutant reducer	Personal preventive	Eye infection	Ear infection	Gastrointestinal infection	Skin infection
1. Taking a pre-swim shower	Effective	*	*	*	*	*
2. Using a pre-swim footbath	Mixed	Mixed	*	*	*	Mixed
3. Wearing a swim cap	Effective	Effective	*	Mixed	*	*
4. Using earplugs	*	Effective	*	Effective	*	*
5. Using swim goggles	*	Effective	Effective	*	*	*
6. Wearing a small swimsuit	P	P	*	*	*	P
7. Wearing no clothing besides a swimsuit	P	*	*	*	*	P
8. Wearing flip-flops	Effective	Effective	*	*	*	Effective
9. Drying and cleaning of swimming-aids	Effective	Effective	*	*	*	Effective
10. Avoiding ingestion of pool water	P	P	*	*	P	*
11. No drinking or eating in the swimming pool	P	*	*	*	*	*
12. Children should not swim without a swim diaper	Effective	*	*	*	Effective	*
13. Taking a restroom break every 60 minutes	Effective	P	*	*	*	*
14. Not swimming with infectious illness	Effective	*	P	P	Effective	P

General prevention of swimming pool-related disease outbreaks can be achieved with reduced anthropogenic pollution or fewer pathogens in the swimming pool; ***Effective*** evidence of effectiveness present; ***Mixed*** mixed evidence of effectiveness present*;* ***P*** plausible but no evidence available*;* ***** not applicable.

ABSTRACTS FROM POSTER PRESENTATIONS

POSTER 1

HIGH PERFORMANCE FILTER MEDIA FOR SINGLE, MULTI-LAYER AND MULTI-MEDIA FILTRATION AT WATER RECLAIMING AND WATER TREATMENT SYSTEMSl

Emmerich M

SIGMUND LINDNER GmbH

Aims

The selection of common quality natural silica sand and silica gravel filter media for water treatment and water reclaiming systems leads to insufficient hydraulics, increased filter bed clogging, enhanced biofouling, higher electrical energy demand, reduced life-cycle, and increased Operations & Maintenance (O&M) costs. Extensive comparative field and laboratory studies since 2010 proved, glass bead filter media can achieve two figure savings for O & M at enhanced filtration performance and lifetime cycles.

Methods

Gravel and sand are natural minerals - their availability and quality has declined rapidly in recent years (Pascal Peduzzi et al, 2014). This is a global phenomenon. Aside from this situation - sand filtration does still have some specific disadvantages due to its material characteristics. Filter running time is relatively short and needs to be backwashed frequently, this is often not effective and/or practical. Pollutant residues lead to encrustations and bio film formation - resulting in the sand filter bed becoming increasingly contaminated. This contamination adversely affects the mechanical filtration process and leads to unwelcome channelling, clogging and blocking - creating a contamination amplifying effect. The filter has to be regularly disinfected and the filtration media needs to be replaced at an early stage. The use of high quality glass beads can completely resolve this issue or at the very least, reduce it considerably. The specific geometry and surface quality of glass beads provide for a dynamic deep-bed filtration. During this process, dirt particles and pollutants are deposited in the pore gaps of the glass bead filter bed - however the specific characteristics of the chemically inert glass beads provide a complete cleaning of the bed when backwashing and rinsing.

Material

Polished glass beads made of soda lime glass

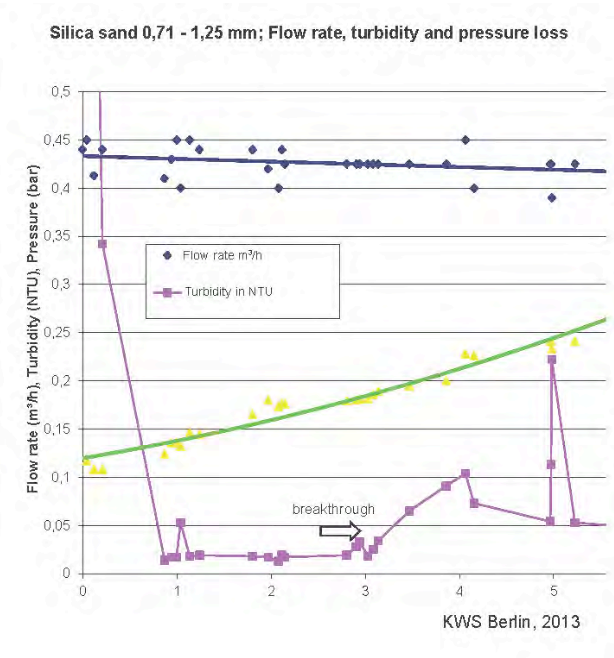
Specific weight:	2.50 kg/l	
Hydrolytic resistance on Glass beads:	HGB 2	(based on DIN ISO 720)
Acidic resistance on Glass beads:	S2	(according to DIN 12116)
Alkaline resistance on Glass beads:	A1	(according to DIN ISO 695)

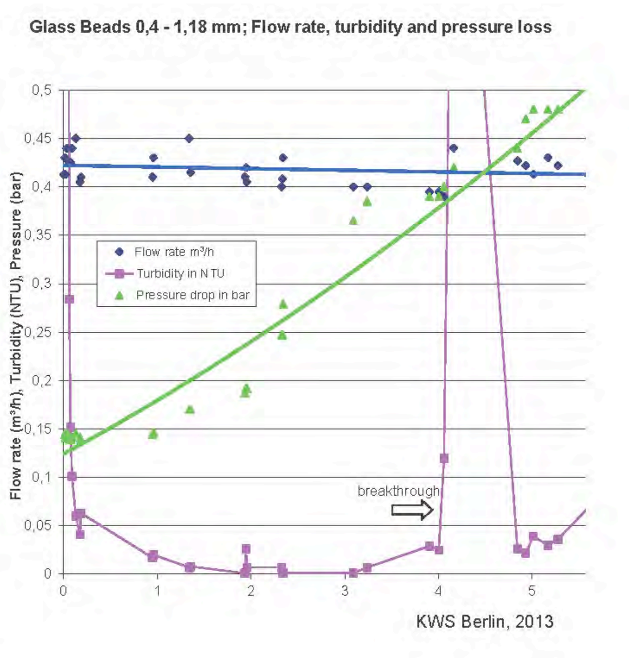
Fields and Application

High performance filter media for single-, multi-layer and multi-media filtration at water treatment, water reclaiming applications and water purifying systems.

Conclusions - Major Advantages of Glass beads
Precise and narrow gradations for an applied filter bed design
Absolutely dust-free filter charging
No pump cleaning after installation necessary, no risk of diffuser clogging
Highly resistant against disinfection & sterilization agents and regenerants
High fracture strength and abrasion resistance for mechanical and chemical stability
Highly effective filtering process due to optimal hydraulic conditions
Superior self-cleaning and fluidization-properties during back wash
Significant reduction of the need of water and energy due to reduced back wash duration
Reduction of chemical agents and extended service intervals
Almost unlimited durability

Results





Compared to sand filtration media a glass bead filter bed offers 25% higher dirt-load capacity between backwash cycles compared with a significantly lower turbidity.

Backwash water savings

Set up	
Back wash time in minutes	6
Diameter of the filter vessel in meter	1,2
Filter area in m²	1,13
Demand of backwash water in m³ per m² filter area	
Glass beads 0,41 - 1,18 mm at 48 m/h backwash velocity	4,8
Quarz sand 0,71 - 1,25 mm at 65 m/h backwash velocity	6,5
Water savings per backwash	
Difference in m³/m² filter area	1,7
Water savings in percentage glass beads vs. quarz sand	26,15%

KWS Berlin, 2013

This comparison of sand filtration media and glass beads shows marked differences regarding fluidization and bed expansion during backwash. The specific properties and backwash characteristics of glass beads provide > 25% water savings.

References

Public Swimming Pools

1.	Freizeitbad Michelbach	D
2.	Best Western, Triberg	D
3.	DRVB Bad Schmiedeberg	D
4.	Badepark Bentheim	D
5.	Thüringentherme, Mühlhausen	D
6.	De grote Koppel, Arnheim	NL
7.	Klinikum Magdeburg	D
8.	REHA-Zentrum Bad Lübben	D
9.	Palm Beach Stein b. Nürnberg	D
10.	Plantsch, Schongau	D
11.	Rosenhof Ahrensburg	D
12.	Fritschiwiese, Zürich	CH
13.	Ostseebad Dierhagen	D
14.	Freibad Grevenmacher	LUX
15.	Naturbad Geiselweid, Winterthur	CH
16.	R. M. Schwimmhalle, Erfurt	D
17.	Geiselweid, Winterthur	CH
18.	Piscine Centre Sportif	CH
19.	Ostparkbad Frankenthal	D
20.	Herschelbad, Mannheim	D
21.	Hallenbad, Frauenfeld	CH
22.	Monte Mare	D

POSTER 2

PHARMACEUTICALS AND ILLICIT DRUGS OF ABUSE IN INDOOR SWIMMING POOL WATERS IN THE EMILIA ROMAGNA REGION, NORTH OF ITALY.

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Aims
There is growing concern about the presence of emerging chemical contaminants in swimming pools. Most studies mainly focused on the presence of disinfection by-products (DBPs) in water. Some hundreds of DBPs have been identified in chlorinated water of the swimming pools, some of which are of particular concern for human health due to their toxicity and/or suspected carcinogenic or mutagenic activity. To date, little information is present in the literature, about the occurrence of pharmaceuticals and illicit drug residues in pool waters although these chemicals are ubiquitous contaminants in the aquatic environment. The main source of these chemicals and/or their metabolites in pool waters are swimmers who eliminate organic substances or sometimes urine and sweat in pool water. The aim of this study was to investigate the occurrence of pharmaceuticals and illicit drugs and their metabolites both in pool and in source waters in a sample of public Italian indoor swimming pools during every day activities and typical managing conditions in order to quantify the actual amount of these compounds and to assess the potential exposure for swimmers, mainly by ingestion.

Methods
The study was performed in 10 public indoor swimming pools located in the Emilia-Romagna Region (Northern Italy). Each swimming pool was visited once and information about the main structural characteristics of the facilities, the pool water treatments and disinfection procedures were collected. Disinfection treatments involved liquid sodium hypochlorite solutions (4 swimming pools), calcium hypochlorite (4 swimming pools) and trichloroisocyanuric acid (2 swimming pools). All sampling sessions were carried out in March - April 2016 in order to obtain waters with a long stay in the pools, as the complete discharge and new charge of water in the pools is generally performed at the end of summer period. Time passed from the last complete change of pool water and the number of swimmers who are daily present in pool waters in each investigated swimming pools were registred, too. During each session, both source (only in 4 swimming pools) and pool water were sampled. We tested for the presence of illicit drugs (cocaine, opioids, amphetamines and cannabis) and/or their metabolic residues and of 31 pharmaceuticals which have been found in significant concentrations in the aquatic environment in Italy, during previous investigations. Among pharmaceuticals, analgesics, antibiotics, anticonvulsants, non-steroidal anti-inflammatory drugs, beta-blockers, diuretics, estrogen and hormones, bronchodilators, gastrointestinal, lipid regulators , anti-cancer were investigated. Chemical analysis was performed by high-performance liquid chromatography – tandem mass spectrometry (HPLC–MS/MS), after solid phase extraction (SPE).

Results

Pharmaceuticals were present in all the investigated swimming pools and 11 compounds were measured at levels above theirs limit of quantification (>LOQ). The most frequently detected pharmaceuticals were anti-inflammatory drugs. Ibuprofen and ketoprofene were present in all the investigated pool waters, with maximum values of 197 and 127 ng/L, respectively. Also anticonvulsants were frequently detected in pool waters, and carbamazepine and, its metabolite 10,11-dihydro-10,11-diidrossicarbamazepine were measured in 8swimming pools. Other pharmaceuticals classes were found in pool waters occasionally (3-8 samples) and at lower concentrations as for instance atenolol, enalapril, and valsartan, while paracetamol, hydroclorothiazide, irbesartan and dehydroerythromycin were found only in 1 or two samples. . . In this study four source water samples are collected. Pharmaceuticals were detected only in one source water, at very low levels.

Among illicit drugs, only cocaine and its metabolites were detected above the limit of quantification in swimming pools waters. Opioids, amphetamines and cannabis derivatives were never detected. Cocaine and its metabolites were found in 8swimming pools, at concentrations ranging from 0.18 to 4.16 ng/L for cocaine, from 1.08 to 48.72 ng/L for norcocaine, from 0.68 to 21.4 ng/L for benzoylecgonine and from 0.12 to 7.33 ng/L for norbenzoylecgonine. No difference in the presence of pharmaceuticals and illicit drugs of abuse are observed among disinfection treatments.

Conclusions

Pharmaceuticals were detectable in all the investigated swimming pools and, among these, anti-inflammatory, anticonvulsants were the most widespread. In general, pharmaceuticals concentrations appear low and in accordance with other studies. These chemical compounds are present in pool waters as a consequence of urine release among swimmers as in source waters illicit drugs are not present, and pharmaceuticals are observed at very low concentrations.

Future research is needed to characterize potential health risks from long-term, low level exposure to these substances, particularly for sensitive sub-populations.

POSTER 3

ASSESSING CYANURIC ACID LEVELS FOR CHLORINE STABILIZATION AND EFFECTIVE DISINFECTION IN SWIMMING POOLS

Oikonomidou ED

Analytical Laboratory of Rhodes, Greece

Aims

To propose an acceptable level for cyanuric acid in swimming pools, in order to balance its stabilizing effect with the negative effects of overuse. There is a correlation between high levels of cyanuric acid and the presence of *Pseudomonas aeruginosa* in swimming pools, even in the presence of free chlorine. Cyanuric acid is a by-product of commercial pool disinfectants commonly used in outdoor pools, such as trichloroisocyanurates and dichloroisocyanurates. Its use is very important in outdoor pools as cyanuric acid acts as a stabilizer for chlorine, reducing photochemical reduction. Cyanuric acid is a mild irritant in case of skin contact, eye contact, ingestion and inhalation. There are no available data on its long term effects. The Joint FAO/WHO Expert Committee on Food Additives and Contaminants (JECFA) has considered the chlorinated isocyanurates with regard to drinking-water disinfection and proposed a tolerable daily intake for anhydrous sodium dichloroisocyanurate (NaDCC) of 0–2 mg/kg of body weight. From a water chemical balance point of view, high levels of cyanuric acid significantly lower pH and bind free chlorine reducing its disinfection ability. Being a stable component it can only be removed by replacing water, thus increasing cost of treatment.

Legislation in Greece does not include cyanuric acid as a regulated parameter, so its use is many times uncontrolled. In the United States, legislation is diverse concerning cyanuric acids. In some states a maximum of 100mg/L is stated, while in others it shouldn't be present at all. Australian legislation sets the limit of 50mg/L. According to W.H.O. guidelines for safe recreational waters, a level of 100mg/L cyanuric acid is set. There are numerous scientific papers comparing cyanuric acid's stabilizing effectiveness with disinfection, both for common bacteria and various algae. In all available research 25mg/L of cyanuric acid produced adequate results, and higher concentrations did not seem to increase stabilization, yet markedly decreased disinfection rates. For the presented work *Pseudomonas aeruginosa* is the bacteria monitored in outdoor pools with regard to cyanuric acid levels. *Pseudomonas aeruginosa* is an aerobic, non-spore-forming, motile, Gram-negative, straight or slightly curved rod with dimensions 0.5–1 µm × 1.5–4 µm. It can metabolize a variety of organic compounds and is resistant to a wide range of antibiotics and disinfectants. *P. aeruginosa* is ubiquitous in water, vegetation and soil and shedding from infected humans is the predominant source of *P. aeruginosa* in pools and hot tubs. In swimming pools, the primary health effect associated with *P. aeruginosa* is otitis externa or swimmer's ear. *P. aeruginosa* is not a regulated parameter in Greek legislation.

Methods

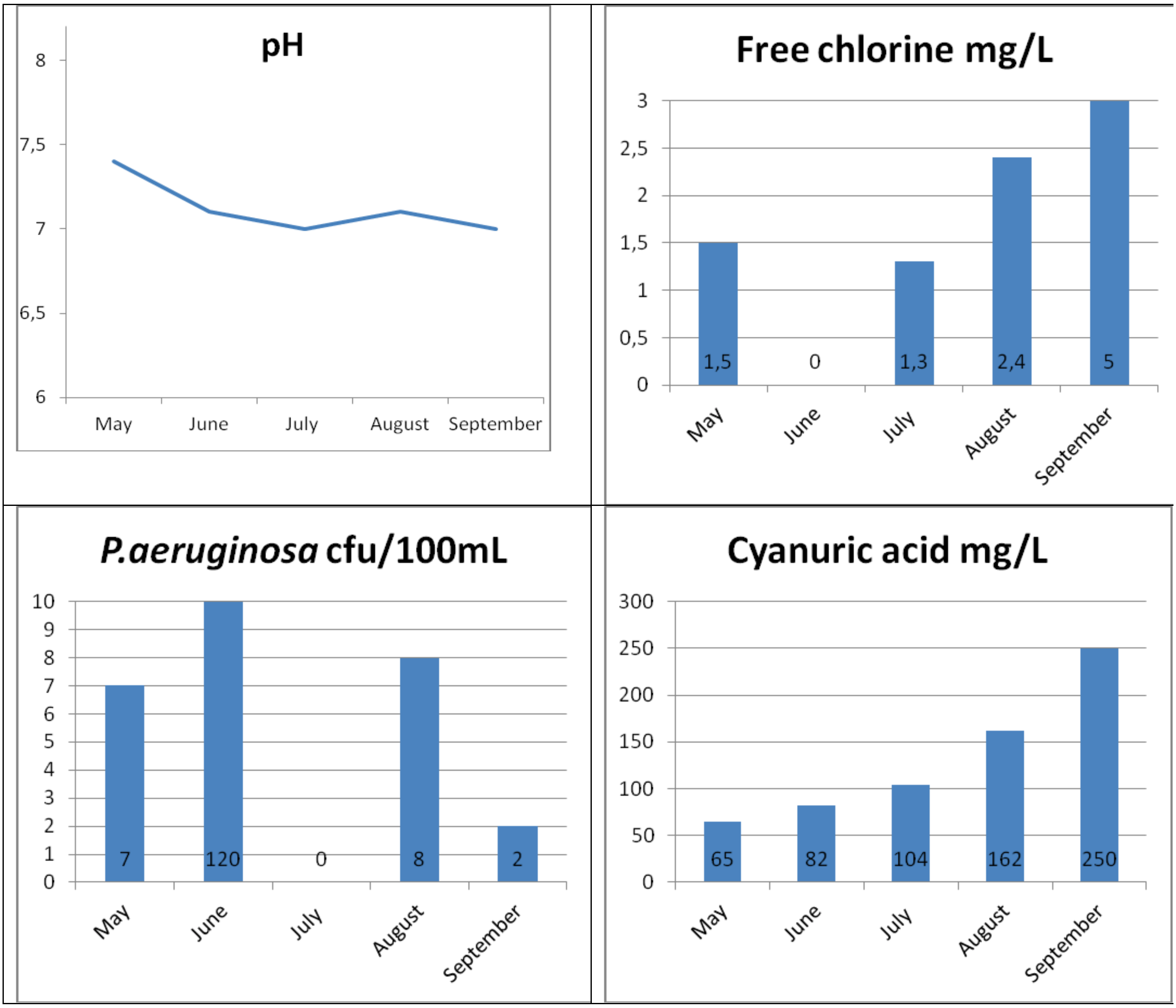
In existing scientific work the effectiveness of cyanuric acid as a stabilizer and potential disinfection inhibitor is tested in laboratory conditions, yet real samples from swimming pools can have different results. Every swimming pool is different in operation, load and current weather conditions, so reproducing results is a problem, therefore results can only be as part of an assessment. Work presented here, provides real results of swimming pool samples, their operation monitored throughout the working season in monthly intervals. Swimming pools tested are in hotels in the Dodekanese area, working in the summer season and most of them are large, outdoor semi-public swimming pools, using potable water as source. Most swimming pool managers use isocyanurates as a means of disinfection, both trichloro-isocyanurate for routine disinfection and dichloro-isocyanurates for shock treatments. The laboratory is privately held, providing sampling services and using accredited testing methods. All samples collected were delivered in less than 2h for sites in Rhodes (8h for sites in the Dodekanese). Presented are measurements for pH (measured electrochemically - Standard Methods 4500-H B), free chlorine (measured colorimetrically, dpd), Cyanuric acid (measured by turbidity, Hach), and *P. aeruginosa* (membrane filtration, ISO 16266 method).

Results

A select number of monitored sites are presented, where high levels of cyanuric acid are measured and the presence of *Pseudomonas aeruginosa* is detected throughout the season. Most sites are outdoor pools of various sizes. Special cases are outdoor pools intended for children. Swimming pools intended for children are very small pools around 25 m^3 capacity and receive high stress from the children using it. Large amounts of cyanuric acid, as well as the significantly lowered pH may cause irritation and the swimming pool may be unsafe due to inadequate disinfection rates, even if highly chlorinated. A few indoor pools are presented where isocyanurates were selected as means of disinfection by the management. Variation of the parameters during the working season, show ever decreasing pH values with steady increase in the levels of cyanuric acid, and presence of *Pseudomonas aeruginosa* even at high levels of free chlorine. Required actions for remediation were proposed in all cases, the responsibility of carrying them out lying with the hotel management.

Outdoor pool A (capacity approx. 80m^3)

	May	**June**	**July**	**August**	**September**
Cyanuric acid (mg/L)	65	82	104	162	>200
P. aeruginosa (cfu/100mL)	~7	>100	N/D	~8	<4
pH	7,4	7,1	7,0	7,1	7,0
free chlorine (mg/L)	1,5	N/D	1,3	2,4	>>3



Conclusions

Results presented validate theoretical conclusions. Presence of high levels of cyanuric acid in swimming pools reduces the disinfection effectiveness of chlorine. *Pseudomonas aeruginosa* survives even with high levels of chlorine. Cyanuric acid is important in stabilizing chlorine for use in outdoor pools, but overuse must be avoided. High levels of cyanuric acid significantly decrease pH, inhibit the disinfecting properties of chlorine and create a protective environment for *Pseudomonas aeruginosa*. Cyanuric acid can be lowered only by significant water replacement therefore increasing the cost of pool maintenance. Cyanuric acid should be a monitored and regulated parameter concerning swimming pool hygiene. Initially, recommended levels of cyanuric acid can be as high as 100mg/L for large outdoor pools in order to balance cost, effectiveness, stability and avoid negative effects. For smaller pools, with capacity 25cm^3 or less, a much lower level can be suggested, preferably 50mg/L or less. In indoor pools use of cyanuric acid is not suggested, since chlorine is protected from photochemical degradation. However, low levels of cyanuric acid, less than 25mg/L, can be accepted.

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POSTER 4

LEGIONELLA RISK ASSESSMENT AND MANAGEMENT FOR SPA WATERS: THE RECENTLY RELEASED ITALIAN GUIDELINES.

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Aims

The “Italian Guidelines on prevention and control *of legionellosis*” released in 2000 were the first document providing updated information about the prevention and control of this severe human infection in Italy., In February 2005 an agreement between Health Ministry and Regional Authorities entitled “Guidelines about *Legionella* risks for managers of spa and touristic-related facilities ” was released in order to provide a useful tool for risk assessment and management for stakeholders, with several technical advices based on the most updated scientific evidences. The newest version of the Italian “Guidelines on prevention and control of *legionellosis*”, released in 2015 according to national work safety regulatory framework, updates and gathers all previous information and topics, and is based on international scientific literature reviews:

Regulatory framework and guidelines content

The most important and complete normative act about work safety in Italy is Legislative Decree 81/2008, which includes the fulfilment of all suitable security measures for the complete prevention and protection activities for all people presents in a work environment. As *Legionella* exposure is a health hazard, because of its classification in Group 2 of pathogen agents, security measures should be implemented after risk assessment procedure as is stated in normative text. The new guidelines describe *legionellosis'* risk control protocol divided in three sequential steps:

- *Risk assessment*: the first stage concerns all features involved in system and overall circumstances correlated to *Legionella* occurrence description. Possibility of infections and outbreaks should also be considered as documental output of this first risk analysis process.
- *Risk management*: all interventions and procedures addressed to completely remove or keep under control all criticisms found in previous stage. All actions undertaken in this stage must be the outcome of a multidisciplinary team strategy on all system features and their relationship with the local environment.
- *Risk communication*: all actions addressed to inform and train involved people (manager, employers, customer, etc)

Many studies have demonstrated wide diffusion of *Legionella spp*. in spa and touristic-related facilities. Thus, prevention and control by a risk analysis is quite important for public health and legal consequences related to *Legionnaires'* disease occurrence.

Risk evaluation must be implemented by a skilled worker responsible of the entire process (*e.g.* hygienist, microbiologist and water engineer with specific expertise, etc.). *Legionellosis* risk is due to several factors and among them the most important are:

- Water temperature ranging between 20 and 50 °C
- Low-use pipeline sections

- Non-continuous or seasonal facilities
- Features and maintenance of water systems and taps (*e.g.* cleaning, disinfection, etc.)
- Features of water supplied to the building water systems (*e.g.* source, *Legionella* substrates availability, disinfection residual occurrence, etc.)
- Obsoleteness, complexity and system dimensions
- Structural modifies of the facility
- Rubber and natural fibres use for gaskets, O-rings and seals devices
- *Legionella* occurrence and concentration

Results and Conclusions

Guidelines provide a checklist for easily gather and compile basic information for a screening evaluation of risk factors. Spa manager has to proceed and revise risk assessment at least every two years (preferably yearly) and whenever situations require it. Based on overall outcomes of risk assessment, a control and maintenance plan must be drafted comprising all specific actions fit for purpose, especially clean and disinfection procedures.

Guidelines provide several prevention measures in order to drive spa manager to reduce and control *Legionellosis* risk. Every time it could be impossible to accomplish all these measures simultaneously, a quick water sampling for *Legionella* analysis must be carried out. Meanwhile corrective measures must be adopted and a monthly-based sampling activity must be scheduled for the first 6 months; afterward sampling must be conducted on a timetable based on overall risk analysis.

After system disinfection, microbiological control must be periodically conducted as following:

- After 48 hours from the end of disinfection activity
- If test result is negative, re-sampling after a month
- If second test is negative too, re-sampling after three months
- If also third test is negative, re-sampling after 6 months or periodically, as required by control plan.

Spa and touristic-related facilities often provide hot tubs as typical device for wellness. This type of devices could be seriously involved in *Legionella* contamination because of the temperature (generally, 30°C or higher), the intense aerosol formation and the complete recirculation (after treatment) of water in use. Control measures for hot tub (with specific dimensional and use requirements) consist in daily replace of the half of the tub water and filtration on sand filter that must be daily back-washed. Paper or polyester filters should not be used in commercial spa or touristic-related facilities. Hot tub water must be automatically and continuously treated with an oxidant biocide (preferably chlorine) injected downstream the filter. Hand-made biocide dosing must be done only in emergency case. Free chlorine residual must reach and keep in the range 0.7-1.5 mg/L. The optimal pH values should be in a range of 7.0-7.6. Pumps and disinfection systems must continously operate. Disinfectant residual concentration and pH value should be measured previous the use and every two hours. Hot tubs commercially exposed, for sale and exhibitions, must comply at the same rules. Guidelines provide specific considerations also about thermal spring waters use as supply waters. Thermal spring water definition is indicated in L. 24/10/2000, No.323 as “natural mineral waters (…) used for therapeutic purposes”. Microflora features and high temperatures (30-40 °C) are favourable conditions for *Legionella* growth Thermal spring waters typically used as inhalation cures (nebulization, aerosol,..), hot tubs and cleaning shower (shower after sludge application) might configure a severe risk for *legionellosis*. Besides,, risk management for thermal spring water systems should consider additional measures consisting of specific clean and sanification procedures for shower jets (decalcification), devices substitution/sterilization for individual treatment inhalator therapy and specific hygiene procedures of the therapy rooms.

POSTER 5

ADVANCED METHODS FOR ASSESSING WATER SAFETY AND QUALITY: APPLICATION ON THERMAL FACILITIES

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Aims

Thermal waters are used for therapeutic or recreational purposes, in form of bath, hydromassage, aerosol, and mud. Their specific therapeutic properties depend on chemical and physical characteristics but also the microbial diversity of these waters can contribute to their curative effects. Thermal muds (peloids) are produced by mixing clayey materials with thermo-mineral waters, and are enriched with organic materials produced by the metabolic activity of microorganisms growing during the maturation process. Thermal muds have peculiar healing properties depending on the kind of clay minerals, the physico-chemistry of the thermal water and the growth and colonization of microorganisms. Parameters like temperature, pH, morphological characteristics of spring, presence and concentration of typical salts can create habitat suitable for the survival and multiplication of opportunistic bacteria, such as *Legionella* spp. In addition, under stressing conditions (i.e., high temperature, low-nutrients, the oxidative and/or osmotic conditions, presence of chemical compounds) *Legionella* spp, can enter in a Viable But Not Culturable (VBNC) state in which they are not detectable by standard culture, but they are still alive and retain their virulence. Recently, it has been developed a new technique named “EMA-qPCR” able to discriminate between viable and dead *Legionella* cells. Ethidium MonoAzide Bromide (EMA) selectively binds DNA of cells with compromised membrane, whereas intact membrane represents a barrier for this dye.
Moreover, the diffusion of Next Generation Sequencing (NGS) and bioinformatics tools offers the opportunity for a more extensive approach for examining the microbial diversity. By analysing the microflora DNA it is possible to detect not only single bacteria and their distribution, but, simultaneously, all the different species interacting in an ecological niche.
The aims of our study are:
- To evaluate the presence of viable legionellae inside thermal water networks by using both traditional culture and molecular methods (qPCR and EMA-qPCR);
- To characterize by NGS technologies the microbial community of thermal water, moving from spring to points of use, and of peloids during the different maturation stages.

Methods
Our study was conducted in a thermal facility of Northern Italy. Its thermal water is sulphurous water with high concentrations of sodium chloride, bromine and iodine, with various therapeutic properties known since the Romans time. Hot spring water gushes out at temperature of 69°C. We collected water samples from spring, wells, tanks and points of use inside thermal facilities. Two litres were analysed by NGS technologies for characterizing the microbiome. Briefly, DNA was extracted, amplified using primers specific for 16S rDNA (containing overhang adapters) and subsequently sequenced through Illumina MiSeq platform. Bioinformatic analysis was performed with 16S Metagenomics app, while microbial biodiversity was computed through EstimateS software. Six litres were analysed by culture (ISO 11731:1998), qPCR and EMA-qPCR for the detection and quantification of *Legionella* spp. In this thermal facility, muds are prepared *in situ* by maturation of clayey virgin materials mixed with sulphurous water. Mud samples were collected from outdoor pools at different stages of maturation and analysed by NGS technologies as described above.

Results
Preliminary results confirm the absence of *Legionella* spp contamination in thermal water by the three methods. By using the NGS technologies, a progressive transformation of microbial community from spring to distal points was observed, due to the appearance of thermophiles species such as *Thiomonas* or *Thiofaba* spp. Microorganisms involved in biofilm formation, such as *Desulfobacca* spp, were found in some sections of the water distribution system. Interestingly, bacteria able to produce lipids, such as *Pelobacter* spp, increased in muds during the late stages of maturation.

Conclusions
Our investigation approach based on the use of NGS technologies for microbiome characterization in both thermal water and muds can significantly improve our knowledge on the relationship between microbial diversity of a thermal spring and its peculiar therapeutic and cosmetic properties. Moreover, sequencing-based microbial community analysis associated with viability qPCR can provide new information on the unexpected presence of waterborne opportunistic and pathogenic bacteria useful to select control measures aimed to guarantee the best water quality and safety for persons attending the thermal facilities.

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POSTER 6

THE EFFECT OF UV TREATMENT ON HIGHLY POLLUTED AND NORMAL OPERATED SWIMMING POOLS

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Abstract
Water samples from 2 indoor public swimming pool facilities with significantly different organic matter concentrations in the recirculation were tested to evaluate UV-induced effects on water chemistry. The aim of the study was to investigate the impact of poor water quality due to increased organic carbon (TOC) and the potential effect of increased nitrate concentration on disinfection by-product (DBP) formation in pool water. Concentration change on total trihalomethanes (TTHM) was investigated utilising medium pressure UV treatment in conjunction with chlorine. Post-UV chlorine consumption increased, UV dose-dependently. The post-UV chlorination clearly induced TTHM formation in both polluted and normal operated pools. However, elevated TOC concentration did not increase significantly the DBP formation. Regarding the brominated fraction of the halogens in the formed TTHMs, it appeared to decrease when the sample was subjected to post-UV chlorination in the normal operated pool, having the opposite result in the highly polluted pool. The addition of nitrate (when subjected to irradiation it forms radicals) and the subsequent post-UV chlorination were contradicting with the radical mechanisms; nitrite shielded the water surface inhibiting the UV penetration and therefore less TTHMs were formed.

Keywords
DBP formation; medium pressure UV lamp; polluted pool; trihalomethane

Introduction

Although chlorine (Cl_2) is extensively used due to its efficiency to kill viruses and bacteria, it has been accused to form disinfection by-products (DBP) and combined chlorine. To eliminate the latter, medium pressure (MP) ultraviolet (UV) lamps are used with the additional risk to enhance total trihalomethane (TTHM) formation (Cassan et al., 2006; Kristensen et al., 2009; Cimetiere and De Laat, 2014) after Cl_2 addition (Spiliotopoulou et al, 2015). All these studies were conducted in normal operated pools with relatively good water quality. The present study aimed to investigate the reaction conditions in a highly polluted pool. The deteriorating water quality was due to the extremely high bathing load – increased total organic carbon (TOC). Pools might also have elevated nitrate concentrations (naturally contained in drinking water). Therefore, water samples were spiked in the laboratory with increased nitrate solution to investigate the effects on DBP formation. Study's findings were compared with a parallel identical study, where the pool was normally operated, aiming to investigate the effect of high TOC and nitrate on DBP formation in UV-treated water samples.

Materials and Methods

<u>*Water characterization:*</u> Free and total Cl_2 were determined utilizing test kits (LCK 310, Hach Lange, Germany). During the experiments the residual Cl_2 was determined by 2,2-azino-bis(3-ethylbenzothiazoline)-6-sulfonic acid-diammonium salt (ABTS), (Pinkernell et al., 2000). Test kits (NO_3^- 09713 and NO_2^- 114776, Merck, Germany) determined nitrate and nitrite, respectively. A Shimadzu ASI-V UVC/Persulphate analyser quantified TOC.

<u>*Pool water:*</u> Pool water was collected from two public swimming pools (Denmark). The two practice basins are typical public pools - temperature at 26 °C, sand filter with flocculation, a side stream activated carbon filter and a hydraulic retention time of 4 h, filling water was non-chlorinated ground water. The two pools differentiated greatly in terms of bathing load. The majority of bathers in the normal operated pool were attending for leisure while few group activities were scheduled weekly. Thus, the amount of people and consequently the organic matter inserted in the pool was well distributed. Conversely, the second pool is a training and rehabilitating pool with very high bathing load (courses are scheduled every 30min approx.) while the users age ranges from 3 to 80 years old. Usually children, teenagers and elder people do not follow the hygienic rules consistently. Therefore, new precursors are continually entering the pool resulting in increased concentrations of TOC and miscellaneous compounds, which might further create DBPs.

<u>*Experiments:*</u> Water samples were collected during regular operating hours and were analysed immediately, determining the water quality (pH, NO_3^-, TOC, free and combined chlorine). Then, they were spiked with a radical initiator (Cl_2 or NO_3^-) and were subjected to irradiation; dose equivalent to UV treatment in full-scale systems. Cl_2 dosage was based on the Cl_2 consumption, to achieve a residual after 24 h within 1-3 mg/L (typical Cl_2 levels) or 31-33 mg/L (high Cl_2 levels). UV treatment was performed in a quasi-collimated beam apparatus with a MP lamp (P=700 W, ScanResearch, Denmark). The TTHM formation was quantified utilizing a Purge & Trap and a GC-MS (Hansen et al. 2012a). The samples were analysed for DBPs before UV exposure in order to establish initial values and after post-UV chlorination to investigate the effect of increased organic matter on DBP formation. To examine the effect of nitrate, samples were spiked with 11.1 mg/L NO_3^--N prior to UV exposure. Data treatment was conducted using MS Excel and Prism Graph Pad.

Results and discussion

<u>*Water characterization:*</u> The initial pH of the 2 pools was similar, 7.0 and 7.2 while the TOC differentiated significantly between the normal operated and highly polluted pool, 1.6 to 7.0 mg/L, respectively. Regarding the nitrate analysis, untreated water sample was analysed and exhibited initial concentrations found to be 4.2 and 1.6 mg/L NO_3^--N. Having determined the initial nitrate concentration, water samples were spiked with nitrate stock solution to achieve nitrate concentrations in the beginning of the experiment equal to 11.1 mg/L NO_3^--N (equivalent to 50 mg/L NO_3^-; upper accepted limit in drinking water). After UV exposure, nitrate spiked samples were analysed for nitrite. The nitrite concentration was 0.6 and 0.8 mg/L-N, respectively.

<u>*Chlorine consumption:*</u> The Cl_2 consumption varied greatly among the treatments in both pools (Fig. 1a). The lowest Cl_2 consumption was observed in solely chlorinated samples (Dark/Cl_2). Cl_2 consumption had the tendency to increase with increasing Cl_2 concentration (Dark/Cl_2 vs. Dark,HighCl_2). The highest Cl_2 consumption was observed in post-UV chlorinated samples (UV/Cl_2,Cl_2) in normal operated pool and in highly chlorinated non-irradiated samples (Dark, High Cl_2) in the polluted pool. The nitrite concentration in irradiated water samples was expected to be increased after Cl_2 depletion due to nitrate photolysis. Nitrite formation might increase the Cl_2 consumption since nitrate was oxidized by Cl_2 to form nitrate (Diyamandoglu et al., 1990). However, no significant change was found regarding Cl_2 consumption when nitrate was added (UV/Cl_2,Cl_2 vs UV/NO_3^-,Cl_2) in both pools.

Effect of increased TOC on TTHMs: The total TTHMs only included the chlorinated and brominated TTHMs; chloroform, bromodichloromethane, dibromochloromethane and bromoform (Fig. 1b). We hypothesised that they were formed from the same precursors and the variation among the different species was due to bromine-chlorine ratio. Low bromine concentration mainly stems from the source water entering the investigated chlorinated pools. In both pools, chloroform was the most pronounced of the THMs. When comparing the non-irradiated chlorinated sample from the normal operated pool with the sample from the polluted pool (Dark/Cl_2) it can be seen that the latest pool originally had double the amount of TTHM.

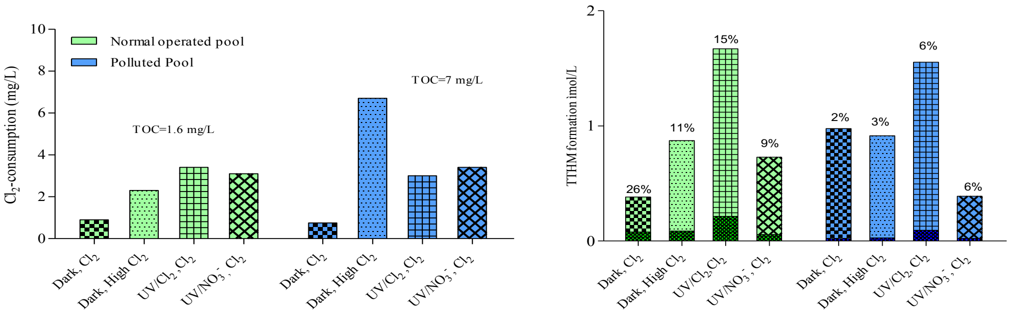

Figure 1. a) Chlorine consumption in 24h. b) TTHM formation in normal operated pool (green) and polluted pool (blue) treated by different procedures including the brominated species (dotted part of the bar graphs). The percentages represent the incorporation of brominated fraction in the TTHM. Dark,Cl_2 = non-irradiated chlorinated sample; Dark,HighCl_2 = non irradiated highly chlorinated sample; UV/Cl_2,Cl_2 = post-UV chlorinated sample; UV/NO_3^-,Cl_2 = 50 mg/L nitrate addition in post-

Post-UV chlorination enhanced TTHM formation (Dark/Cl_2 vs. UV/Cl_2,Cl_2) in both pools; being in agreement with a previous study (Spiliotopoulou et al. 2015). It should be noted that the TTHM induction was higher in the clean pool that in the polluted one. Regarding the brominated THMs, a reduction was found in the normal operated pool and a slight increase in the case of the polluted pool. UV treatment makes the organic compounds in the pool water more reactive towards chlorine and thereby can act as precursor for THM formation. Examining the TTHMs as a sum of the four THMs, it was seen that the post-UV chlorinated sample (UV/Cl_2, Cl_2) formed more DBPs than the samples with simulated long-term residence time (Dark,HighCl_2).

To sum up, the widely applied swimming pool treatment, post-UV chlorination does not enhance further the TTHM formation when higher organic matter is present in the water.

Effects of radicals on DBP formation: During UV treatment, several processes such as photolysis of Cl_2 or nitrate can produce hydroxyl radicals. The highly reactive and non-selective hydroxyl radicals activate organic matter in swimming pool water, and consequently form increased amount of TTHM when subsequently chlorinated (Glauner et al., 2005). However, our results are contradicting, since the nitrate addition in the normal operated pool resulted in increased TTHM formation compared to non-irradiated samples (Dark/Cl_2 vs. UV/NO_3^-,Cl_2) and reduction in the polluted pool (Fig. 1b). Additionally, in both pools, there was a notable decrease of TTHMs between the post-UV chlorination and nitrate addition prior to post-UV chlorination treatments (UV/Cl_2,Cl_2 vs. UV/NO_3, Cl_2). A possible explanation might be that nitrate strongly absorbs UV light, having as a result to shield the water surface from the UV light penetration, and therefore, further reactions are inhibited.

Conclusions

- The high TOC did not contribute notably neither in chlorine consumption nor in DBP formation in post-UV chlorination treatment

- Samples with elevated nitrate concentrations stimulated the least TTHM formation

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POSTER 7

BACTERIOLOGICAL EXAMINATION OF SWIMMING POOLS AND SPA WATER SAMPLES IN NORTHERN GREECE DURING 2011-2016: IS PSEUDOMONAS AERUGINOSA A BETTER POLLUTION INDICATOR?

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The risk of illness or infection associated with recreational water environments is mainly associated with faecal water contamination. Many of the outbreaks related to pools and similar environments have occurred because of not applied or inadequate disinfection. Non-faecal human shedding into the pool water or surrounding area is also a potential source of pathogenic organisms such as *Pseudomonas aeruginosa*. The aim of the current study is to describe and evaluate the bacteriological examination of 2844 swimming pool and jacuzzi/spa water samples in Northern Greece during 2011-2016 period. Bacteriological examination of recreational water includes heterotrophic bacteria, total coliforms and *Escherichia coli* according to Greek Hygienic Regulation and the European Directive 2006/7/EC. *P. aeruginosa* is a significant agent of opportunistic infection in aquatic environments and was also examined in the aforementioned samples. We aimed to indicate the importance of including *P. aeruginosa* as a recreational water quality indicator in the revised version of Greek Hygienic Regulation. Data analysis was performed using statistical package SPSS 22.0. The association between categorical variables was assessed with the chi-square test or the Fisher's exact test, whenever more appropriate, at 5% significance level. The quality of all types of swimming pools was evaluated as excellent as less than 5% was found not to meet the regulations throughout 2011-2016 period. In the small percentage of samples that did not meet the regulations, medians of the indicators were slightly higher than limits. Considering the presence and concentration of *Pseudomonas aeruginosa,* the number of samples that would not meet the standards would differ significantly. *P. aeruginosa* was detected in a larger amount of samples than E.coli which indicates that *P.aeruginosa* should be assessed as an important factor. At last, over time the frequency of isolation of *P. aeruginosa* was remarkably reduced perhaps because of staff vigilance and better compliance with the maintenance instructions concerning swimming pools. In conclusion, we believe that *P. aeruginosa* affects significantly the compliance of samples to the regulations and should be included in the revised version of Greek Hygienic Regulation.

POSTER 8

NEW INSIGHT IN AIRBORNE LEVELS OF CHLORAMINES IN INDOOR SWIMMING POOLS: COMPARISON OF OFF-LINE ANALYTICAL METHODS WITH ON-SITE SIFT-MS.

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Introduction
Swimming pool disinfectants and disinfection by-products (DBPs), especially trichloramine, have been associated with respiratory health effects, including asthma and respiratory irritation. Existing methodologies to measure trichloroamine are based on the adsorption of the sum of chloramines with impingers or impregnated filters and cannot distinguish between the different chloramine species. Nevertheless, these methods have been used extensively in environmental health studies under the general assumption that trichloramine is the predominant airborne specie.

Aims
The main objectives of this study are to review existing analytical methods for airborne chloramines and to achieve a better understanding of the release, formation and distribution of chloramines in the indoor air of swimming pools. This will contribute to new insights in the interpretation of measurement results for environmental health studies. In this study a comparison of three indirect analytical methods was made: As_2O_3 filter method (Hery), DPD/KI impinger method (Predieri and Giacobazzi) and sulfite impinger method (Cimetiere and De Laat). Selected ion flow tube mass spectrometric technique (SIFT-MS) was used for the validation of the analytical methods.

Methods
With SIFT-MS it is possible to distinguish between different inorganic chloramines in air: trichloramine, dichloramine and monochloramine. This unique feature is used to validate existing analytical methods for chloramines in a newly developed experimental set-up (see Figure 1) which made it possible to simultaneously measure the release of chloramines in the air and the decrease of chloramines in the aqueous test solution. To better assess the consequences of the experimental results additional measurements with all four techniques were carried out in an indoor swimming pool. Measurements were conducted at the side of the pool and above the water surface.

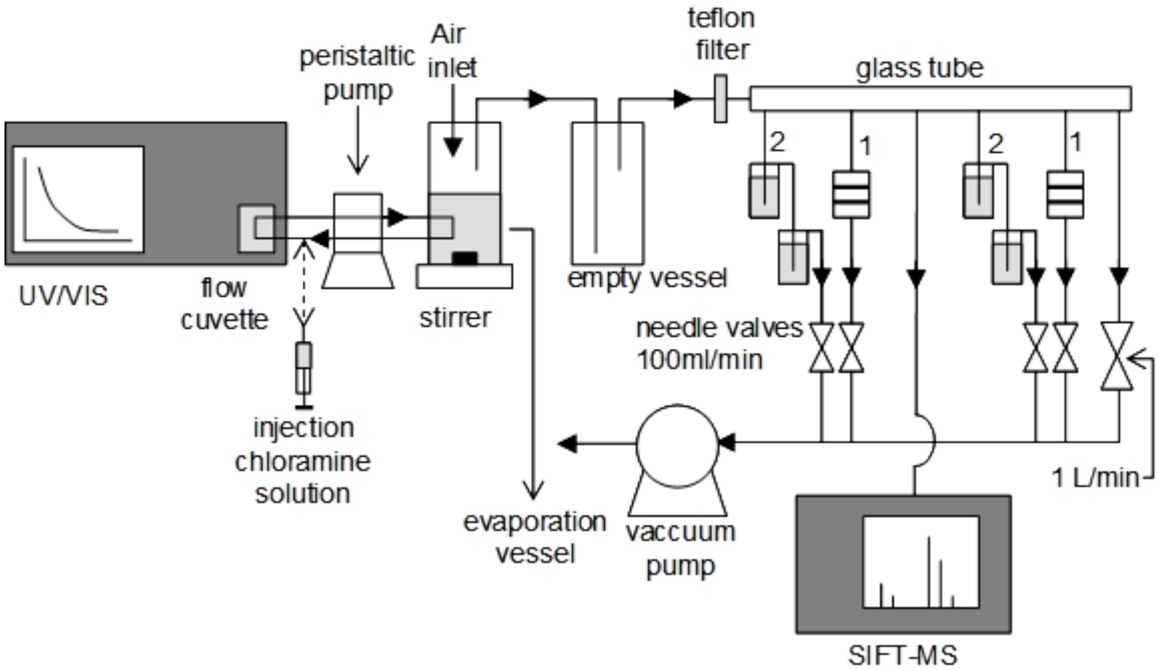

Figure 1: Schematic representation of the laboratory set up for comparison and validation analytical methods (1 = filter method, 2 = impinger method)

Results

The As_2O_3 filter method shows good collection efficiency for trichloramine (99 ± 8 %), but also captures other organic and inorganic chloramines. Although, this was already known, the assumption was always that trichloramine was the predominant airborne specie, therefore little interference was expected. In this study, SIFT-MS measurements in indoor swimming pool air show that the distribution of airborne chloramines is more complex and also substantial amounts of dichloramine and dichloromethylamine are released in the air (see Table 2). When the As_2O_3 filter sampling method is used, a substantial overestimation of the NCl3 concentration is unavoidable. The DPD/KI impinger method by Predieri and Giacobazzi captures not only chloramines but also other chlorinated DBPs and dichlorine gas. Using this sampler to monitor airborne trichloramine levels, will result in a mayor overestimation of the true concentration levels. However, this feature makes it a possible marker for the total exposure to halogenated compounds. A new sulfite impinger method, based on the principles of Cimetiere and De Laat, is developed for dichloromethylamine. Although, this method shows good collection efficiency (95 ± 11 %) and specificity, a large volume needs to be sampled to measure the low airborne concentration levels present in indoor swimming pools. SIFT-MS measurements suggest that the elevation of airborne chloramine levels is partly associated by sampling of water aerosols. Furthermore, above the water surface strongly elevated airborne chloramine and chlorine levels were found compared to measurements at the side of the pool.

Table 2: Overall results from the measurements with SIFT-MS, DPD/KI impinger method, As_2O_3 filter method and sulfite impinger method.

Pool		Instruction Pool		competition pool		instruction pool		competition pool	
Activity		baby swimming		school swimming		free swimming (high activity)		rescue swimming	
People		ca.20		ca.35		35-50		ca. 25	
water temperature		32°C		27 °C		28 °C		27 °C	
Type of measurement		pool border	water surface	pool border	water surface	pool border	water surface	pool border	water surface
SIFT-MS (µg/m3)		(n=6)	(n=2)	(n=6)	(n=1)	(n=3)	(n=1)	(n=2)	(n=4)
NH_2Cl		<2	6	<2	<2	11	17	<2	<2
$NHCl_2$		84	460	67	451	91	288	63	196
NCl_3		119	1007	77	671	57	741	52	175
CH_3NCl_2		42	365	34	186	24	190	23	60
Cl_2		45	902	41	556	36	612	33	186
Chloramines (µg/m3)	CV (%)	(n=2)		(n=2)		(n=2)		(n=2)	
Sum (As_2O_3)	4	174		104		306		106	
Sum (DPD/KI)	12	589		525		1013		561	
CH_3NCl_2	-	<30		<30		<30		<30	

Conclusions

Although with this study the processes related to the release, formation and distribution of chloramines are not completely understood, the results show clearly that sampling method and -strategy have a big influence on the outcome of monitoring studies in indoor swimming pools. Furthermore, this has consequences for the interpretation of measurement results for environmental health studies, because measured concentration levels can either overestimate or underestimate the real exposure to airborne trichloramine.

POSTER 9

EXPOSURE TO DISINFECTION BY-PRODUCTS IN SWIMMING POOLS IN HUNGARY

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Aims

Disinfection is essential for safe pool operation. However, the most commonly used chlorine based disinfectants react with organic compounds in pool water and form chlorinated organic compounds. These compounds may cause eye, throat or skin irritation, and some even pose more severe health risk. The inhalation of these by-products is the main risk factor. The factors leading to high concentration of chlorinated organic compounds are still not fully understood. The aim of this study was to assess the concentration of trihalomethanes (THMs) in the pool water and air, and to understand which factors can lead to high concentration in the air.

Methods

We studied 45 water (25 pool and 20 feed water) and 50 air samples from 25 pools. Water samples were taken from the feed and the pool water. Water samples were analysed for THMs (4 compounds), haloacetic acids (6 compounds), absorbable halogenated compounds (AOX), active chlorine and microbiological parameters. Air samples were collected at 150 and 40 cm height. The concentration of THMs and microbiological agents (fungi and bacteria) were determined in the air samples.

Results

THM concentration in 4 pool water samples (16%) was higher than the national limit value of 50 µg/l. Chloroform was the main contaminant among the investigated compounds. One of the feed water samples from a municipal water supply was also characterized by high THM concentration. Haloacetic acid concentration was also high. AOX was higher than the suggested limit value in the case of 26 samples (52%) (6 of them were feed water). The sum of THM and haloacetic acid concentrations does not correspond to the high AOX concentration determined for the same sample. The microbiological quality of the pools was compliant with the national standards, only one pool water had microbiological problem (high heterotrophic plate count).
The concentration of chloroform ranged between 11.6 and 131.5 µg/m^3 in the air samples. In general, similar THM concentration values were observed for the samples collected at 40 and 150 cm. There was no clear link between the concentration of THMs determined in the pool water and the corresponding air samples. The effect of evaporation of THMs from other pool(s) located close to the investigated pool might be an explanation for this observation since the pools are usually not chlorinated simultaneously and the concentration of THMs in the air are affected by all pools located at the same area.

Conclusion

There is currently no regulation for pool air quality in Hungary. This was the first study to support setting air quality standards. Results show that overdosing of the disinfectants is a frequent practice to maintain microbiological safety, as pool operators are often unaware of the risk of disinfection by-products. In some cases, the feed water (potable water) had already elevated levels of DBP, which was further aggravated by pool disinfection. Data will be used to assess quantitative health risk.

POSTER 10

ASSESSMENT OF HYDROTHERAPY POOLS IN HOSPITALS AND REHABILITATION CENTERS IN ATHENS, GREECE

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Introduction

Exercise in a hydrotherapy pool is often considered as essential for treating a number of serious diseases like paraplegia, strokes, brain paralysis, rheumatoid arthritis, orthopedic ailments, post surgery conditions and gynecological conditions. In this study hydrotherapy pools were inspected in the Athens area, in the light of two recently issued regulations.

Materials and Methods

In the survey 8 hydrotherapy pools were included and 34 samples were collected. In situ free residual chlorine, pH and the water temperature were measured. Samples were taken from the water body of pools, tubs and whirlpools. Swab samples were taken from the walls of empty tubs and from the equipment (floating beds, toys, auxiliary equipment, weights, and flotation devices). Before sampling and with the support of an appointed member of the staff, a check list was completed in order to collect information regarding legal matters as well as construction, water circulation, cleaning, sanitation, aeration, lighting, water & air quality and the staff basic education and training. At the laboratory samples were analysed for Total Mesophilic Counts, Total Coliforms, *E.coli, P. aeruginosa*, *S. aureus*, *L. pneumophila*, using methods described by international standards.

Results

Free chlorine, pH and the water temperature

The water temperature was measured 28-40°C. pH values varied 7.3-8.5 and free residual chlorine 0,55 – 3,5 ppm.

Microbiological quality of the water

With reference to the current regulations, out of the 20 water samples collected from pools, tubs and whirlpools, 50% violated one microbiological parameter, 12,5% two parameters while 37,5% were suitable for use. None of the samples exceeded the limit value of 100cfus/ml of the regulation and they were all negative for Total Coliforms, *E.coli* and *L. pneumophila.* Nevertheless 38, 2% of the samples were positive for *S. aureus* (1-120 cfus/100ml) and 8,8% were positive for *P. aeruginosa* (73-200 cfus/100 ml). All equipment items were found to be of acceptable microbiological quality with the exception of a wheelchair of use in the pool on which recovered 120 *S.aureus* cfus/ ml.

The results of the check list

The major in-compliances with the new regulations of the 8 hydrotherapy pools are presented in Table 1.

Table 1: Summary results of a check list completed by appointed member of the staff in hydrotherapy pools in Athens, Greece (N=8 pools)

No qualified, trained manager and/or personnel	80%
Uncontrolled access to the pool	75%
No data for alkalinity	62,5%
Excessive chlorination	50%
No measurements for relative humidity	50%
No UV disinfection	25%
Water no transparent	12,5%
Poor or absence of management and control records	12,5%
Poor showering procedures for patients	12,5%
Poor cleaning conditions	12,5%
No overflow channel	12,5%
No safe access ladder to the pool	12,5%
No qualified, trained manager or personnel	80%

Conclusions

Most pools seem to violate microbiological parameters for *P. aeruginosa* and *S. aureus* counts even though they were often found hyperchlorinated. The pool management seem to be really week due to the lack of education and training of the staff. The correct application of the new regulations need a lot of work on behalf of the pool management. Nevertheless is really essential and often crucial to the patents well being and health.

POSTER 11

MICROBIOLOGICAL ASSESSMENT OF THE STUDENTS' HANDS DURING LABORATORY PRACTICE

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Introduction
The hands' microbiome consists of permanent and transient microflora. The transient microflora is directly related to the transmission of pathogenic microorganisms both to patients and to inanimate things, therefore hand hygiene is directly related to this transmission. Laboratory technologists should respect personal hygiene rules but also the laboratory management should make sure that they are informed and comply with national and international guidelines.

Aims
The aim of the study was the assessment of the students' information on hand's microbiome, on protection procedures when working in medical laboratories and on the hand washing technique. For this purpose the target group was students of the Department of Medical Laboratories of the Technological Educational Institute of Athens.

Materials and methods
A total of 348 students from 12 laboratory practice classes participated in the survey. Hands' samples collected from the students were cultured on blood agar plate with 5% blood concentration, before and after hand's washing. Participants were asked to fill in a questionnaire. The questionnaire was prepared with reference to previously published studies and to standard WHO relevant questionnaires. The questionnaire included questions on students' socio-demographic characteristics and information on students' general hand washing knowledge, practices, and skills. Some questions aimed to the investigation of the student's knowledge acquired during their studies and how they apply it during their work in a clinical laboratory practice class. Both, the cultures results and the information collected through the questionnaires were statistically processed using Excel 2013 and SPSS 22.0

Results
The questionnaire: The students participating at the survey were attending the following four laboratory classes: General Microbiology - 27% (n=94), Bacteriology - 12.6% (n=44), Analysis of Biological Fluids and Secretions - 9.8% (n=34) and Haematology III - 9.2% (n=32), miscellaneous classes (≅5%). The statistical analysis the questionnaires resulted to the following outcomes: 13% (n=45) of the students did not know that the hand's microbiome includes pathogenic microbial species. 5% (n= 15) of the students never wash their hands during laboratory exercises and the majority of the students, 51.4% (n=179) wash their hands at the end of laboratory classes only. 19% (n=66) of the students never or rarely wear gloves during laboratory exercises, while 41% (n=143) need the teacher's encouragement to wear gloves. 45% (n=157) of the students declared that they are not washing their hands because of carelessness, while 30% (n=104) they do not consider it as necessary. 30% of the students do not roll up their sleeves or remove their jewellery when they wash their hands. 32%(n=110) of them do not know the correct hand washing technique. 35.6%(n=124) of

them do not use an antiseptic solution after hand's washing. A lot of them, 17% (n= 59) didn't know that there are instructions and manuals for proper hand washing even though relevant information and instructions have been included in their syllabus and laboratory text books. 27.6% (n= 96) of them only knew the "12 movements hand washing technique" introduced by the World Health Organization.

Microbiological cultures The Microbiological quality of students' hands was based on the number of colonies recovered on blood agar plates and after statistical analysis via the statistic program SPSS. A comparison was carried out between the average counts of microbial colonies that grew from the sample before and after hand's washing. A relative reduction of 47% with p-value $<0.05=0.002$ was calculated after hand's washing in total , without taking into consideration the washing procedure the application of the correct technique or other parameters.
A very interesting result was that 32% (n = 111) of the samples cultures of the students hands recovered an increased microbial load after hand washing while the remaining 68% (n = 237) a decreased one . Conducted case controls revealed that parameters, such as the genre of the laboratory course, holding time, gender and age, significantly affected the reduction or increase of the microbial load in students hands.

Conclusions
This study examined students' general and specialised, related to their studies and future professional career, hand washing knowledge, practices and skills. Hand hygiene is the most important factor of contamination of both laboratory samples and humans. The results were somehow disappointing, therefore greater attention and more emphasis should be paid to the student's education on hygiene and biosecurity standards, even more when the students will be professionals as laboratory technologists

Key words: Protection methods, hand washing technique

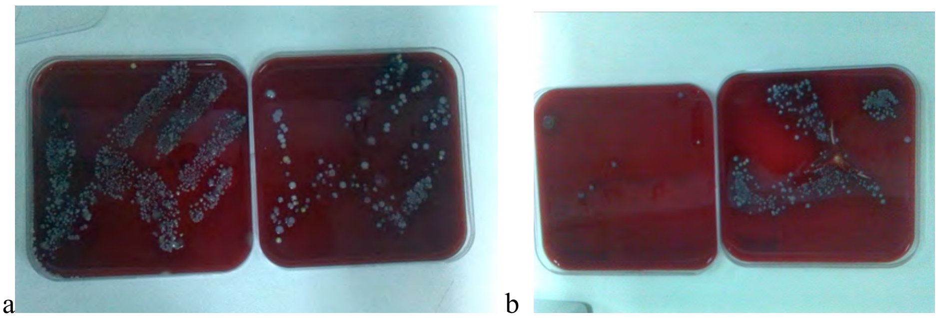
a  b

Figure 1: Hand cultures from student's hands on blood agar base before and after washing. (a) a reduction of the number of microbial colonies is observed (b) an increase of the microbial colonies is observed after washing

POSTER 12

RISK MANAGEMENT AND SAFETY IN SWIMMING POOL: THE USE OF PERSONAL PROTECTIVE EQUIPMENT (PPE) FOR LIFEGUARDS.

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Background

Personal protective equipment, commonly referred to as "PPE", is defined as equipment worn to minimize exposure to serious workplace injuries and illnesses. These injuries and illnesses may result from contact with chemical, radiological, physical, electrical, mechanical, or other workplace hazards. Personal protective equipment may include items such as gloves, safety glasses and shoes, earplugs or muffs, hard hats, respirators, or coveralls, vests and full body suits. (OSHA, 2016).

PPE should be provided and worn where:

a) Hazards cannot be otherwise prevented or suitably controlled, *e.g.* By engineering or administration controls, total enclosure, substitution;

b) Complete protection is essential, *e.g.* In some occupational environments with uncertain levels of hazards' or

c) Legislation requires it. (*e.g.* Standards Australia, 1986).

It is important to ensure that PPE is "fit for purpose" for the activity it is being used for. Incorrect selection of PPE may lead to injury or death.

Sometimes it is not practical to expect that a single item of PPE will protect the user from all hazards which they may be exposed to, nor is it appropriate to expect that all designs of particular PPE will protect the user in the same way.

In 2016, the International Life Saving Federation has approved a Position Statement titled *"Use of Personal Protective Equipment (PPE)"*. This document, based on expert consensus, is here focalized for lifeguards acting in swimming pool.

Methods

During a water emergency, a lifeguard's priority must always be his or her own safety. An assessment of the surroundings should be made before entering into swimming pool. A hazard identification and risk assessment be completed for activities that will expose lifeguards to hazards:

- The performance capabilities and specific characteristics of PPE be assessed to determine suitability for each activity;
- PPE be fitted properly to the user to ensure the efficiency of the equipment in protecting the user is not reduced;
- Specific medical conditions of the user be taken into account that may prevent someone from using PPE.

PPE approved for use by lifesaving organizations should comply with national and international standards and relevant local legislation and regulations. PPE sold and purchased within Europe should have the CE marking affixed (European Commission, 2015).

ILS (2008) sees the implementation of risk assessments for all aquatic locations, including swimming pools, as a key element of the strategies to reduce injury and loss of life or other adverse impact in the aquatic environment. A generic framework and the main elements of the risk management process identified are:

- Communication and consultation
- Establish the context
- Risk identification
- Risk analysis
- Risk evaluation
- Development of a risk mitigation plan
- Monitor and review

Results

PPE in an aquatic lifesaving context should be worn by lifeguards whenever they will be exposed to a hazard that cannot be eliminated or minimised by other means, such as substitution, isolation, engineering and administration.

Lifeguards operate in an environment with associated inherent risks, some of which are impossible to eliminate and difficult to mitigate through higher order risk mitigation strategies such as substitution, isolation, engineering and administration (Figure 1).

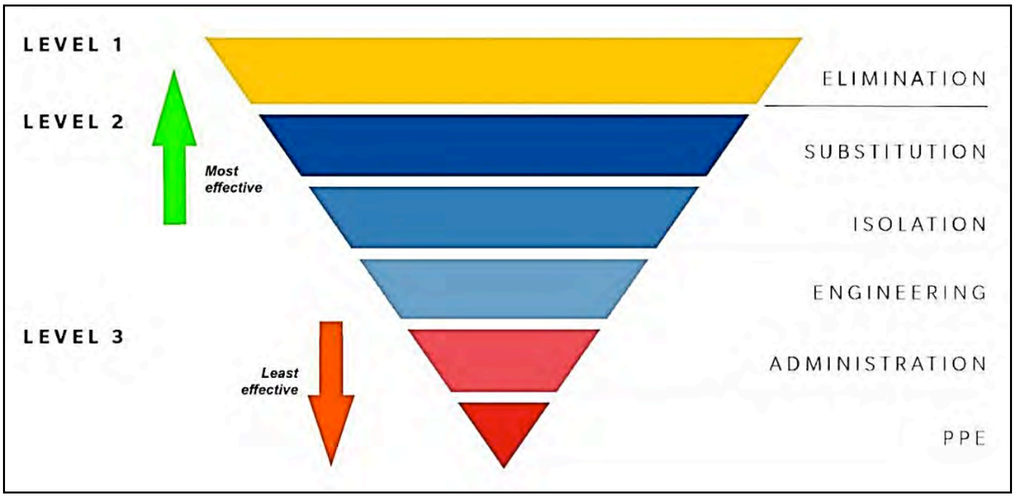

Figure 1: The hierarchy of control (adapted from SafeWork Australia, 2011)

Lifeguards are often called upon to put themselves in danger to save the lives of others in difficulty, however should always take precautions to ensure that they are not putting themselves in unnecessary danger. PPE is an additional option for lifeguards to further minimise the risks associated with their duties. Lifesaving organisations have a range of PPE available to lifeguards for use. PPE must be in close proximity to lifeguards at all times. PPE should include breathing barriers, non-latex disposable gloves, protective eyewear, etc. Some examples, for swimming pools, are shown below (Table 1).

Table 1: Examples of PPE for lifeguards operating in swimming pools.

Type of PPE	Examples use in lifesaving	Application
Protective garments	Non-latex disposable gloves, breathing barriers	First aid / infection disease protection (also during rescue breathing)
Eye protection	Face shields, goggles, safety glasses, sunglasses	• UV eye protection • Splash protection from hazardous chemicals • Protection from infectious disease
Respiratory devices	Oxygen tanks, air supply respirators	Under water search and diving (*e.g.* scuba diving swimming pool)
Face protection	Face masks, pocket masks	• Resuscitation • Splash protection from hazardous substances
Skin protection	Long sleeved shirts, hats, sunscreen	Sun protection (*e.g.* outdoor pool)
Hearing protection	Earplugs, ear muffs	When operating around noise for extended periods of time

Conclusions

1. Effective risk management practices should be used by lifeguards to eliminate or minimise risks posed to them by hazards in their operating environment by means other than PPE; that is by implementing more effective risk mitigation strategies such as engineering controls, or by adopting a different system of operation.
2. If the risk to lifeguards cannot be eliminated or minimised through higher order mitigation strategies, PPE must be worn whenever lifeguards could be exposed to the identified hazard.
3. Any secondary risks associated with the usage of PPE should be assessed, and where intolerable minimised, prior to PPE being implemented for the purposes of lifeguarding. If the secondary risks of using PPE remain intolerable after mitigation, alternative measures must be taken to minimise the risk or exposure to the hazard eliminated.