3rd IWA Resource Recovery Conference

the international water association

Conference Programme

www.iwarr2019.org

8 - 12 SEPTEMBER, 2019

VENICE, ITALY

CO-ORGANIZERS

SMART-Plant

UNIVERSITÀ POLITECNICA DELLE MARCHE

UNIVERSITÀ di VERONA

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

PATRONAGES

MINISTERO DELL'AMBIENTE

UTILITALIA
imprese acqua ambiente energia

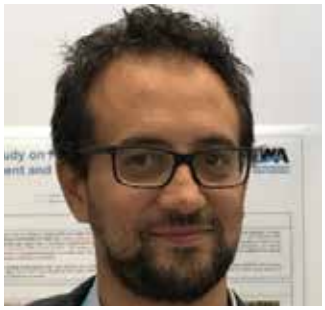
GITISA
Gruppo Italiano di Ingegneria Sanitaria Ambientale

GRICU
GET INNOVATION

SUMMARY

Welcome

Dear Colleagues,
On behalf of the organizing committee, we are honoured and delighted to welcome you to the 3rd IWA Resource Recovery Conference 2019 and it is our great pleasure to welcome you to Venice!



DR. FRANCESCO FATONE
Professor of Chemical-Environmental Engineering
Coordinator of EU-H2020 "SMART-Plant" Innovation Action
Università Politecnica delle Marche
Ancona - Italy

DR. ILJE PIKAAR
Senior Lecturer in Environmental Engineering
School of Civil Engineering
University of Queensland
Brisbane - Australia

The overall theme of the conference is Resource Recovery from Water from concept to standard practice. The strategic objective of the conference is to highlight the importance and showcase opportunities of embedding resource recovery as a key consideration in urban water management. Resource recovery from water is a fast-evolving field with various recent innovations currently being scaled-up and demonstrated in relevant large European Horizon2020 and international innovation actions. This conference represents an excellent opportunity to showcase these recent innovations, to learn and discuss the latest scientific innovations as well as practical experiences with full-scale implementation of innovative approaches enabling resource recovery from water.

This conference goes beyond the technological aspects of resource recovery from water and will play host to 300+ professionals and practitioners from around the globe across a range of disciplines including researchers, utilities, water professionals, technology providers, policy makers, business developers, consultants as well as market segments and industries outside of the water sector that can valorize the recovered resources.

All participants are warmly encouraged to attend different sessions as a means to stimulate debate and encourage multidisciplinary collaboration.

We wish you a successful and enlightening conference!

Francesco Fatone and Ilje Pikaar
IWA RR 2019 Chairs

Co-organizers

IWA Resource Recovery from Water Cluster brings together R&D, water industry and materials users, and to promote economically and environmentally attractive approaches to resource recovery.
https://iwa-network.org/groups/resource-recovery-from-water-cluster/

H2020 Innovation action SMART-Plant "Scale-up of low-carbon footprint material recovery techniques in existing wastewater treatment plants"
http://smart-plant.eu/

Università Politecnica delle Marche - Italy
Group of Water and Waste Environmental Engineering
https://www.univpm.it/Entra/Universita_Politecnica_delle_Marche_Home/L/1

University of Queensland – Australia
School of Civil Engineering
https://www.uq.edu.au/

Università degli studi di Verona – Italy
Department of Biotechnologies
https://www.univr.it/en

GENERAL INFORMATION

CONGRESS ORGANISING SECRETARIAT

Via Sassonia, 30 - 47922 Rimini – Italy
Before and after the Conference:
Phone +39.0541.305811 - Fax +39.0541.305842
E-Mail: acxbooking@adriacongrex.it

During the Conference:
The Organising Secretariat will be located in the Reception Desk
Staff members are available at the Organising Secretariat Desk to assist you for any inquiry.
Staff members are also available throughout the Conference Venue and can be identified by their badges and "Staff" T-shirts.

Opening hours:
Sunday, September 8th, 2019 from 10.00 to 18.00
Monday, September 9th, 2019 from 8.00 to 18.00
Tuesday, September 10th, 2019 from 8.30 to 18.00
Wednesday, September 11th, 2019 from 8.30 to 18.00

Participants are required to register at the Reception Desk upon presentation of their confirmation letter (printed or electronic version). Each participant will receive a Conference Kit, a badge and tickets for the services purchased online (i.e. Gala Dinner, excursions).

VENUE

San Servolo Congress Center
San Servolo Island
30170 Venice, Italy

HOW TO REACH VENICE

From Marco Polo Airport
Venice has a modern airport situated in the mainland at Venice – Tessera.
You may choose among gthe following transportation options:

- ATVO Line no. 35: Bus service to Piazzale Roma, 20 minutes journey, one way ticket € 8,00
- ALILAGUNA Service: blue and red motor boat lines to St. Marco Square, 60 minutes journey, one way ticket € 15,00
- Private water taxi , prices on request

From Venice S. Lucia Railway Station
You can use the ACTV water buses that offer different transportation schedules all day long. For timetables and routes please check http://actv.avmspa.it/content/orari-servizio-di-navigazione.Private taxis are available at the main exit of the station

From A4 Motorway Exit
Follow indications to Venice Parking areas of Tronchetto and/or Piazzale Roma where you can find a variety of parking lots. From there you can reach S. Marco Square by waterbus no. 2.

HOW TO REACH THE VENUE

San Servolo is an Island in the south of Sant'Elena del Lido, not far from Venice and its Lido.
You can reach San Servolo Island from Venice by ferryboat.
There is a direct ferryboat line , no. 20, from San Marco Square. Pick up Point at Riva degli Schiavoni:

SAN MARCO/SAN ZACCARIA "B" - SAN SERVOLO - SAN LAZZARO DEGLI ARMENI (on request) - SAN SERVOLO - SAN ZACCARIA "B"
Departure time every 20 minutes from 6.55 untill 01.20 (last departure from San Zaccaria)

LINEA 20 **S.ZACCARIA - S.SERVOLO - S.LAZZARO - LIDO CASINÒ e viceversa**
IN VIGORE DAL 13 AGOSTO 2019

LIDO Casinò				08:05		08:35		09:05							13:30		14:15
S.MARCO-S.ZACCARIA "B"	06:55	07:20	07:45		08:15		08:45	-	09:15	09:45	10:30	11:10	11:50	12:30	13:10	-	13:55	-
S.SERVOLO	07:05	07:30	07:55	-	08:25	-	08:55	-	09:25	09:55	10:40	11:20	12:00	12:40	13:20	-	14:05	-
S.LAZZARO	-	07:35	08:00	08:10	08:30	08:40	09:00	09:10	09:30	-	10:45	-	12:05	-	13:25	13:35	14:10	14:20
S.SERVOLO	-	07:40	-	08:15	-	08:45	-	09:15	09:35	-	10:50	-	12:10	-	-	13:40	-	14:25
S.MARCO-S.ZACCARIA "B"	07:15	07:50	-	08:25	-	08:55	-	09:25	09:45	10:05	11:00	11:30	12:20	12:50	-	13:50	-	14:35
LIDO Casinò			08:05		08:35		09:05								13:30		14:15	

												(A)	(A)	(A)	(A)	(A)		
LIDO Casinò						17:30		18:15		19:00								
S.MARCO-S.ZACCARIA "B"	14:40	15:15	15:45	16:10	16:35	17:10	-	17:55	-	18:40		19:40	20:30	21:30	22:30	23:30	00:30	01:20
S.SERVOLO	14:50	15:25	15:55	16:20	16:45	17:20	-	18:05	-	18:50	-	19:50	20:40	21:40	22:40	23:40	00:40	01:30
S.LAZZARO	14:55	15:30	-	-	16:50	17:25	17:35	18:10	18:20	18:55	19:05	-	-	-	-	-	-	-
S.SERVOLO	15:00	15:35	-	-	16:55	-	17:40	-	18:25	-	19:10	-	-	-	-	-	-	-
S.MARCO-S.ZACCARIA "B"	15:10	15:45	16:05	16:30	17:05	-	17:50	-	18:35	-	19:20	20:00	20:50	21:50	22:50	23:50	00:50	01:40
LIDO Casinò						17:30		18:15		19:00								

SHUTTLE SERVICE

During the Conference (September 9, 10, 11) you will find a free shuttle service from San Zaccaria to San Servolo. Departure time from 7.45 until 8.45 from San Zaccaria M.V.E. "B".

REGISTRATION FEE

IWA RR2019 Registration Fees	LATE REGISTRATION (until September 5, 2019)
HIGH INCOME COUNTRY	
NON IWA	€ 650,00
IWA	€ 550,00
YWP (YOUNG WATER PROFESSIONAL) <35 YEARS	€ 500,00
STUDENT <28 YEARS	€ 350,00
ACCOMPAYNING PERSON	€ 100,00
LOW INCOME COUNTRY	
NON IWA	€ 400,00
IWA	€ 300,00
YWP (YOUNG WATER PROFESSIONAL) <35 YEARS	€ 250,00
STUDENT <28 YEARS	€ 250,00
ACCOMPAYNING PERSON	€ 100,00

PLEASE NOTE YOU CAN REGISTER ON SITE ONLY BY PAYING BY CREDIT CARD

The registration fees for participants include:

- Admission to the Program Sessions
- Program Timetable (hardcopy)
- Conference Web App
- Access password to the Abstract Electronic book (ISBN book)
- Admission to Exhibition Area
- Certificate of attendance (sent via e-mail, upon request)
- Welcome Cocktail that will be held on Sunday, September 8th in San Servolo garden, from 18.00.
- Morning and afternoon coffee breaks that will be served in Grecale Area
- Light lunches that will be served in Grecale Area
- Conference kit

The registration fee for accompanying person includes:

- Welcome cocktail
- Admission at the Congress Venue
- Dedicated social program (Bacaro Tour + Discovery St. Marco Square)

BADGE INFORMATION / LOST BADGES

Badges are nominative, not transferable and cannot be lent to anyone during the Conference.
All participants are kindly requested to wear their badge throughout their permanence at the Congress Venue. Participant and Speaker badges allow entrance to all scientific sessions (limited to seat availability), exhibition spaces, coffee areas and all other activities open to individual participants.
Exhibitor badge allows entrance to the exhibition, coffee break areas and service spaces. Please consider your badge as a valuable ticket. In case of loss, the full registration fee will be charged.
NO BADGE = NO ENTRY

OFFICIAL LANGUAGE

The official language of the Conference is English. No simultaneous translation will be provided.

EXHIBITION SPACES

The Conference venue includes an Exhibition Area, located in Colonne Hall (First Floor).

WI-FI

Free internet wi-fi connection will be provided everywhere in the Conference venue areas.
Wi-fi network name “SanServolo”.

CLOAKROOM / LUGGAGE STORAGE

A free-of-charge cloakroom / luggage storage is available at Room no. 9 at the Ground Floor.

DISABILITIES

San Servolo allows access to people with disabilities and wheelchairs users, despite the presence of some gravel roads and small ramps in the open spaces. An accompanying person is recommended. Please contact the Organizing Secretariat for information about accessible ways.

LOST AND FOUND SERVICE

For any lost and found object and if you need any assistance, please contact the Organising Secretariat.

Patronages

Ministero dell'ambiente e della tutela del territorio e del mare MAATM
Italian Ministry of Environment
https://www.minambiente.it/

UTILITALIA
Italian association of water, waste and energy utilities
www.utilitalia.it

Gruppo Italiano di Ingegneria Sanitaria Ambientale
Italian Group of Environmental and Sanitary Engineering
https://gitisa.it/

Gruppo di Ricercatori di Ingegneria Chimica dell'Università
Chemical Engineering University Group
http://www.gricu.it/

Special thanks to:

ATS – Alto Trevigiano Servizi
Water utility of Treviso Province (Italy) co-organizing and supporting the technical visit to resource recovery sites in Treviso province
https://altotrevigianoservizi.it/

Veritas - Veneziana Energia Risorse Idriche Territorio Ambiente Servizi
Largest public multiutility of Veneto Region (Italy) co-organizing and supporting the technical visit to Fusina treatment Plant
https://www.gruppoveritas.it

Acque Veronesi
Public water utility of Verona Province (Italy) co-organizing and supporting the organization of IWA RR 2019
http://www.acqueveronesi.it/index.asp

Supporting Platforms

Water Europe – Technology & Innovation
watereurope.eu
Water Europe is the recognized voice and promotor of water-related RTD and innovation in Europe. It aims to enhance the performance of the water service providers, water users, and technology providers, in a sustainable and inclusive way, and to contribute to solving water-related societal challenges.

ESPP – European Sustainable Phosphorus Platform
phosphorusplatform.eu
The European Sustainable Phosphorus Platform (ESPP) brings together companies and stakeholders to address the Phosphorus Challenge and its opportunities.

WAREG – European Water Regulators
www.wareg.org
WAREG is a group of economic regulators who have assembled to learn from each other's experiences and support the development of the effective regulation of the water and wastewater industry in Europe.

EurEau - European federation of national water services
www.eureau.org
EurEau represents national drinking and wastewater service providers from 29 countries, from both the private and the public sectors.

APE - Aqua Publica Europea
www.aquapublica.eu
APE is the European Association of Public Water Operators. It unites publicly owned water and sanitation services and other stakeholders working to promote public water management at both European and international level.

Sponsor

PLATINUM SPONSOR
SALSNES FILTER | www.salsnes-filter.com

Over 27 years ago, we designed the first rotating belt filter to provide customers with a highly efficient and reliable technology that could maximize solids separation and decrease costs. Today, we continue to lead the development of this technology from our office and manufacturing facilities in Namsos, Norway. We are a brand in the Trojan Technologies group of businesses, located in Ontario, Canada. We have installed over 900 filters around the world, giving us a global footprint in municipal and industrial markets. Our customers use the Salsnes Filter system in municipal wastewater treatment plants, and for a host of industrial applications such as cruise ships, aquaculture, biofuel production, pulp & paper, food & beverage and others. A Salsnes Filter system can completely replace conventional primary solids separation, thickening and dewatering system. Or, it can augment existing primary treatment to improve plant performance and reduce overall costs. Compared to conventional systems, a Salsnes Filter system can:

- Reduces Plant Footprint – Replaces or augments conventional treatment in 1/10th the space
- Improves Secondary Treatment – Eases demand on secondary treatment by removing TSS and BOD
- Optimizes Biogas Production – Produces higher Volatile Solids contents in primary sludge
- Enhances Resource Recovery – Separate resources from wastewater to be reused or recycled.

GOLD SPONSOR
SUEZ INTERNATIONAL | www.suez.com

With 90 000 people on the five continents, SUEZ is a world leader in smart and sustainable resource management. We provide water and waste management solutions that enable cities and industries optimize their resource management and strengthen their environmental and economic performances, in line with regulatory standards. To meet increasing demands to overcome resource quality and scarcity challenges, SUEZ is fully engaged in the resource revolution. With the full potential of digital technologies and innovative solutions, the Group treats over 45 million tons of waste a year, produces 4.4 million tons of secondary raw materials and 7.7 TWh of local renewable energy. It also secures water resources, delivering wastewater treatment services to 66 million people and reusing 1.1 billion m3 of wastewater. SUEZ generated total revenues of 17.3 billion euros in 2018.

SILVER SPONSOR
VEOLIA WATER INTERNATIONAL ITALIA | www.veolia.com

Veolia group is the global leader in optimized resource management. With over 171,000 employees worldwide, the Group designs and provides water, waste and energy management solutions which contribute to the sustainable development of communities and industries. Through its three complementary business activities, Veolia helps to develop access to resources, preserve available resources, and to replenish them. In 2018, the Veolia group supplied 95 million people with drinking water and 63 million people with wastewater service, produced nearly 56 million megawatt hours of energy and converted 49 million metric tons of waste into new materials and energy. Veolia Environnement (listed on Paris Euronext: VIE) recorded consolidated revenue of €25.91 billion in 2018 (USD 30.6 billion).

BRONZE SPONSOR
SCAE | www.scae.eco

SCAE, established in 2002 in the heart of the industrious Italian North East, as constructor of machineries for wastewater treatment plants and anaerobic plants (biogas), establishing a company and market leader in the field. SCAE is a reality built on a consolidated business experience with a high-level management structure that includes more than 30 employees and collaborators. SCAE works in full cooperation with engineering's offices, multi-utilities, installers and various kind of industries (agribusiness, chemical, biogas, pharmaceutical,…) to supply a complete support in the realizing Waste Water Treatment Plants or part of them. Our features are high quality products, continuous professional training and an after-sales service with qualified technical assistance.

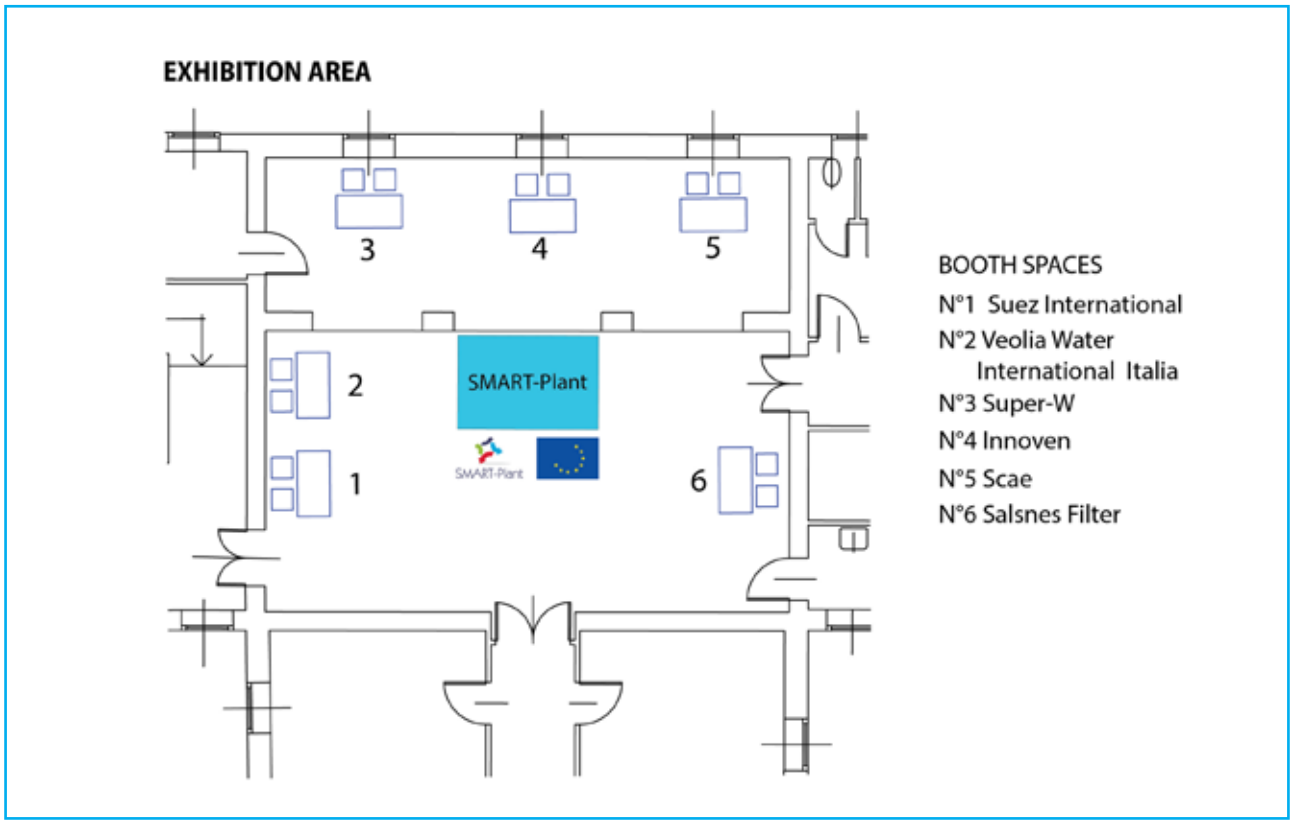
BRONZE SPONSOR
INNOVEN - INNOVATION FOR THE ENVIRONMENT | www.innoven.it

Since 2013 InnovEn Srl provides consultancy, auditing and eco-innovative solutions concerning bio-based and circular economy, wastewater and organic waste valorization, towards better technical, environmental and economic sustainability. Innovative processes and solutions have been succesfully delivered in public and private water and waste utilities, as well as medium and large industries that are aiming at greening their production and business. The international profile of InnovEn is demonstrated by five European Horizon2020 projects where InnovEn is partner (H2020 NoAW, H2020 Afterlife, H2020 Glopack, H2020 Ingeen, H2020 Usable packaging).

BRONZE SPONSOR
ECOMONDO - KEY ENERGY | www.ecomondo.com

Ecomondo - Key Energy is a well established show in Italy and one of the most representative events in Europe for the processing and recycling of all kinds of waste, water treatment, efficient use and transformation of raw materials, solutions in energy from renewable sources, energy efficiency, smart cities. Global Water Expo is the section dedicated to all phases of integrated urban water management and the water cycle, from extraction to return to the environment or the efficient re-use for industrial or irrigation purposes. The 2018 edition showcased 1,300 companies on 116,000 sqm., 90,500 attendees, 200 conferences with 1,500 speakers. The next edition will be held at Rimini Expo Centre from November 5th to 8th, 2019. Ecomondo- Key Energy is organized by Italian Exhibition Group (IEG), one of the most representative Italian Trade show and convention organizer born through the merger of 2 Italian expo centres: Rimini and Vicenza.

Meet our sponsors from September 8th, h. 15.00 to September 11th h. 18.30 in the exhibition area at Colonne Hall, 1st floor.



H2020 PROJECTS

IWA RR 2019 was promoted and organized by Horizon2020 SMART-Plant and the following EU H2020 projects on water and circular economy, receiving funding under the European Union's Horizon 2020 Research and Innovation Programme.

SMART-Plant
"Scale-up of low-carbon footprint material recovery techniques in existing wastewater treatment plants"(H2020 GA 690323 www.smart-plant.eu)

HYDROUSA
"Demonstration of water loops with innovative regenerative business models for the Mediterranean region" (H2020 GA 776643 www.hydrousa.org)

nextGen
"Towards a next generation of water systems and services for the circular economy" (H2020 GA 776541 www.nextgenwater.eu)

PROJECT-O
"Demonstration of planning and technology tools for a circular, integrated and symbiotic use of water" (H2020 GA 776816 www.eu-project-o.eu)

SUPER-W
"Sustainable Product, Energy and Resource Recovery from Wastewater" (H2020 GA 676070 www.superw.ugent.be)

These projects have received funding from European Union's Horizon 2020 Research & Innovation Programme

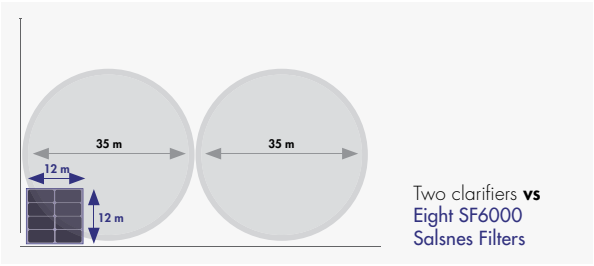
A TROJAN TECHNOLOGIES BUSINESS

salsnes filter™

It's Time to **Rethink Primary Wastewater Treatment**

Reduces
Plant Footprint

Replaces or augments conventional treatment in 1/10th the space.



Two clarifiers **vs** Eight SF6000 Salsnes Filters

Improves
Secondary Treatment

Eases demand on secondary treatment by removing TSS and BOD.

Optimizes
Biogas Production

Produces higher Volatile Solids content in primary sludge.

Enhances
Resource Recovery

Separates resources from wastewater to be reused or recycled.

Toilet Paper from Wastewater | Cellulose Pellets | Asphalt, Bio Plastics, & More!

www.salsnes-filter.com

Program Committee

Francesco Fatone – Italy

Conference Co-Chair and Coordinator of the European H2020 “SMART-Plant” Innovation Action

Ilje Pikaar – Australia

Conference Co-Chair and Secretary of the IWA RRfW Cluster

David Stuckey – United Kingdom and Singapore

Co-Chair, IWA RRfW Cluster

Olaf van der Kolk – Netherlands

Co-Chair, IWA RRfW Cluster

Jeremy Guest – USA

MC member IWA RRfW Cluster

Willy Verstraete – Belgium

MC member IWA RRfW Cluster

Céline Vaneeckhaute – Canada

MC member IWA RRfW Cluster

Korneel Rabaey – Belgium

MC member IWA RRfW Cluster

Ana Soares – United Kingdom

MC member IWA RRfW Cluster

Scientific Committee

Adrian Oehmen, University of Queensland, Australia
Anna Laura Eusebi, Polytechnic University of Marche, Italy
Bruce Jefferson, Cranfield University, UK
Camilla Braguglia, IRSA-CNR, Italy
Carlos Chernicharo, UFMG, Brazil
Carmen Teodosiou, Iasi University, Romania
Cees Buisman, Wetsus, The Netherlands
Christian Remy, Berlin Competence Center for Water, Germany
Claudio Di Iaconi, National Research Council, Italy
Costas Noutsopoulos, National Technical University of Athens, Greece
Damien Batstone, University of Queensland, Australia
David Bolzonella, University of Verona, Italy
Debora Fino, Politecnico di Torino, Italy
Evina Katsou, Brunel University of London, UK
Francesco Fatone, Polytechnic University of Marche, Italy
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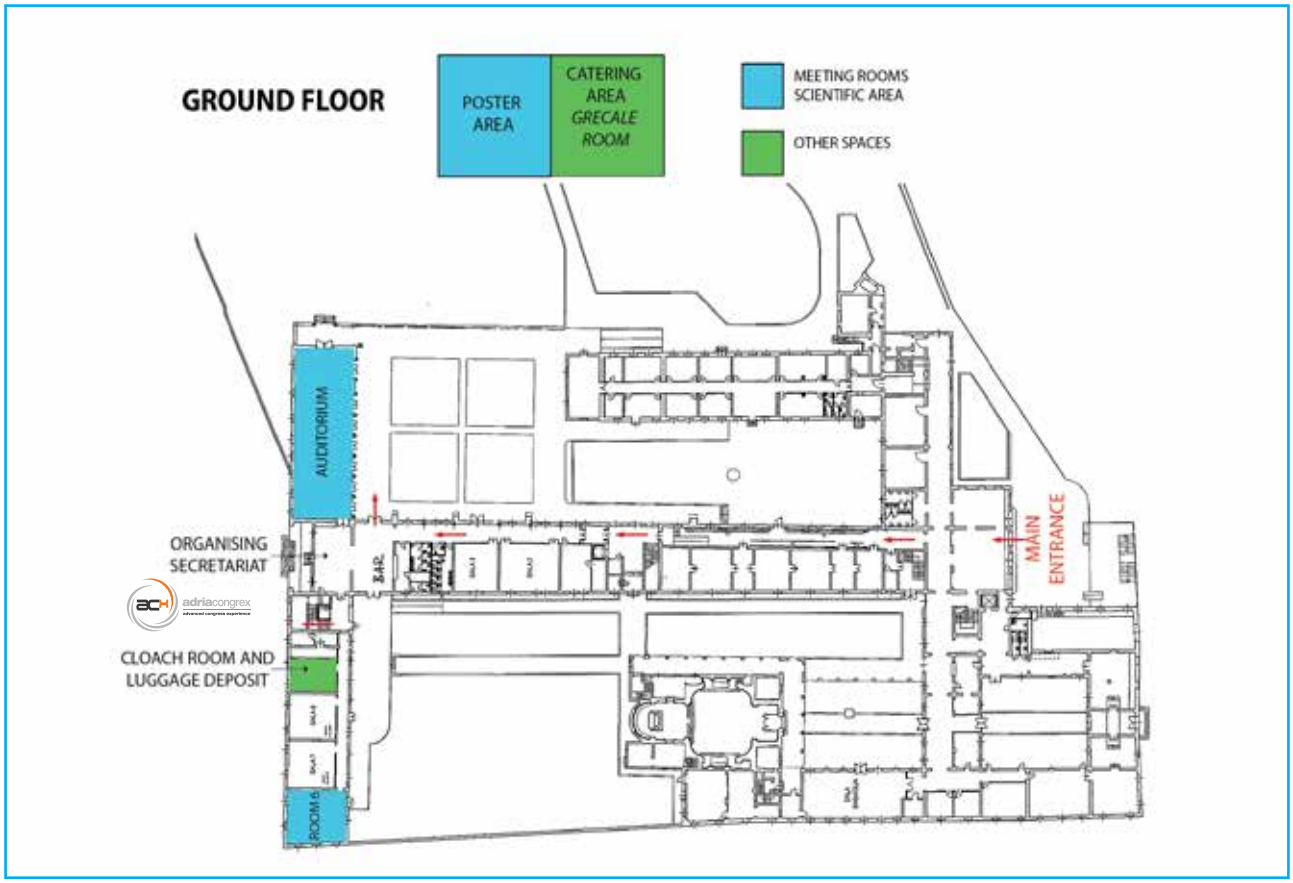
Joaquim Comas, Catalan Institute for Water Research, Spain
Juan Antonio Baeza, Autonomous University of Barcelona, Spain
Juan Lema, University of Santiago de Compostela, Spain
Julian Sandino, Jacobs, USA
Jurg Keller, University of Queensland, Australia
Kees Roest , KWR, The Netherlands
Lars Angenent, University of Tubingen, Germany
Ludwig Hermann, Proman Consulting, Austria
Maite Puijan, Catalan Institute for Water Research, Spain
Mark van Loosdrecht, Delft University of Technology, The Netherlands
Mauro Majone, University of Rome “La Sapienza”, Italy
Miriam Otoo, IWMI, Colombo, Sri Lanka
Paolo Pavan, University of Venice, Italy
Paul Jensen, University of Quensland, Australia
Piet Lens, University Ireland Galway, Ireland
Riccardo Gori, University of Florence, Italy

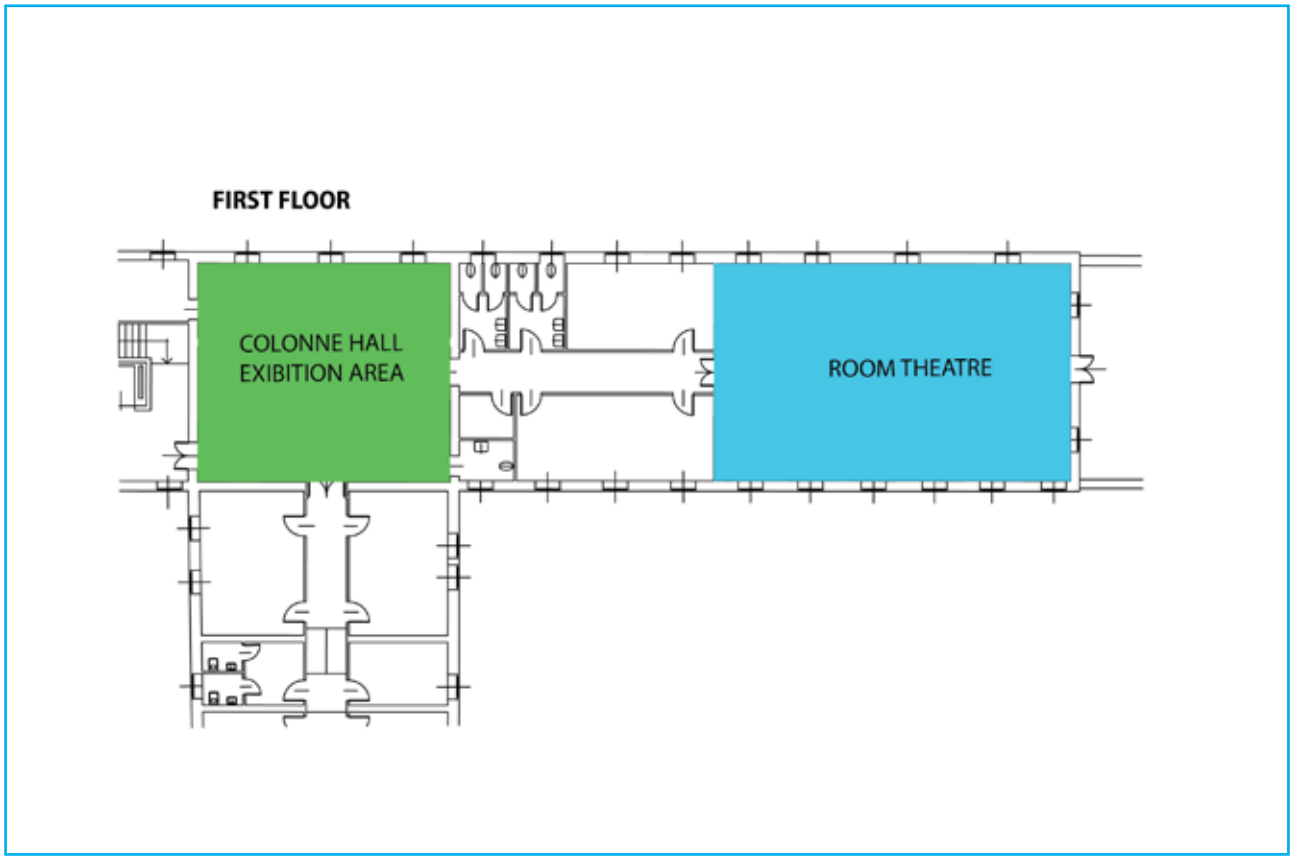
Roberto Canziani, Polytechnic of Milan, Italy
Sergio Ponsà Salas, University of Vic, Spain
Siegfried Vlaeminck, University of Antwerp, Belgium
Simos Malamis, National Technical University of Athens, Greece
Thomas Wintgens, FHNW, Switzerland
Tim Hulsen, University of Queensland, Australia
Xia Huang, Tsinghua University, China
Xiaochang Wang, Xi'an University of Architecture and Technology, China
Ying Yu Law, Nanyang Technological University, SCELSE, Singapore
Zhou Yan, Nanyang Technological University, NEWRI, Singapore

Local Organizing Committee

Conference Co-Chairs:	**Francesco Fatone** and **Ilje Pikaar**
IWA Cluster Co-Chairs:	**David Stucky** and **Olaf van der Kolk**
H2020 Coordinators:	**Gijs Du Laing, Simos Malamis, Jos Frijns, Christos Makropoulos, Ilaria Schiavi, Almudena Hospido, Christian Loderer**
Local Water Professionals:	**Anna Laura Eusebi, Nicola Frison, David Bolzonella, Paolo Pavan, Cristina Cavinato**
YWP Team:	**Alice Botturi, Giulia Cipolletta, Vincenzo Conca, Cinzia Da Ros, Alessia Foglia, Gözde Özbayram, Matteo Tartini, Saba Daneshgar, Federico Battista, Çağrı Akyol, Enrico Marinelli, Cecilia Bruni, Serena Radini**
Responsible for YWP Events:	**Nicola Frison**
Conference Secretary:	**Marika Fantoni**

Congress Area





Scientific Information

ABSTRACTS BOOK

All accepted abstracts will be published in the electronic Book of Abstracts "3rd IWA Resource Recovery Conference 2019" (ISBN: 9788894470000)
The Book of Abstracts will be available for download **from the Conference website using a password communicated by mail to registered participants.**

IWA RR 2019 INTERACTIVE MOBILE APP

Download the conference APP here: https://whova.com/portal/iwarr_201909/?source=text_link and search for "IWARR2019" to meet participants and be updated on the Program and latest announcements.

ORAL PRESENTATIONS

The oral presentations sessions will be held in different rooms as scheduled in the Oral Program and Program Timetable. The presentation time for oral presentations will be 15 minutes. All presenters are requested to keep to their allotted time and be regularly registered.
All presenters are requested to upload their presentation in the session room no later than two hours before the beginning of the session.
Presenters must be in the session room at least 15 minutes before the start of the session and must remain there until the end of the session. Presentations will be given in English language only, supported by video projections from PC only.

POSTER SESSIONS

The abstracts selected for poster presentations will be displayed in the Poster Area as reported in the Congress area Map. Posters may be mounted as early as on Sunday 8th at 15.00 and should be removed on Wednesday 11th, by 12.00.
All the posters will be displayed for the whole duration of the Conference in the poster area.
Poster sessions are scheduled on Monday 9th and Tuesday 10th from 13.00 to 14.30h.
Presenters needs to be available next to the poster to discuss results and answer questions.

PROJECTION

Only PC data projection is available in every room. Slides must be worded in English only;
please copy your work - prepared using MS Power Point or equivalent program – on a USB Pen drive.
FOR MAC USERS ONLY! If your presentation is on MAC computer, please make sure to convert your presentation in pc-compatible Power Point. If this is not possible, you can use your MAC computer, but you need to bring your own adapter and meet the technicians well in advance, to be sure that your presentation runs properly or anticipate a back-up solution.

CERTIFICATE OF ATTENDANCE

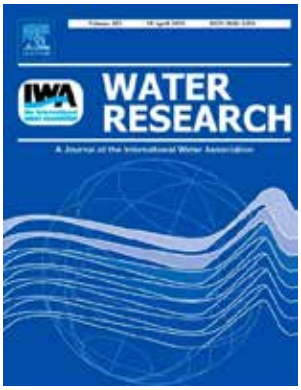
Participants attending the whole event will receive their certificate of attendance by e-mail after the Conference, upon request to the Secretary desk or by email to acxbooking@adriacongrex.it

CHANGES IN PROGRAM / ERRATUM

For scientific and/or technical reasons the Scientific Committee and the Secretariat reserve the right to make changes to the Conference program.

Special Issues

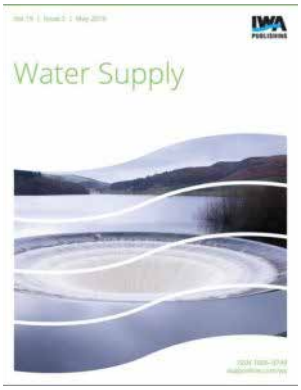
All accepted papers will be published in electronic conference proceedings (ISBN). Selected papers will be considered for peer review for publication in IWA and ISI indexed journals, in special issues associated with IWARR2019.



Water Research

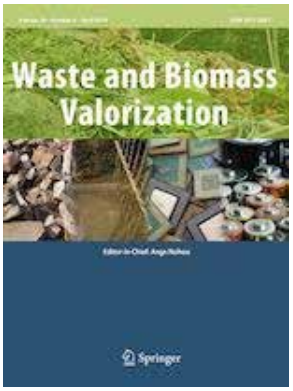
Special Issue on Resource Recovery from Water: From Concept to Practice
Water Science & Technology: Water Supply

Water Science & Technology



Water Science & Technology: Water Supply

H2Open Journal



Waste and Biomass Valorization Special issue

Ingegneria dell'Ambiente

SCIENTIFIC PROGRAM

Plenary Presentations

CONFERENCE OPENING PLENARY PRESENTATION:

September 8th, h.17.00-18.30, 17.00-18.30, Room Auditorium (audio-video connection to Room Theatre):
"PAST (developed technologies to full scale) PRESENT (currently working on) FUTURE (2020 – Visions to 2050) OF RESOURCE RECOVERY FROM WATER CYCLE"

Mark van Loosdrecht

Professor in Environmental Biotechnology at Delft University of Technology

Prof. van Loosdrecht's scientific interests are mainly related to biofilm processes, nutrient conversion processes and the role of storage polymers in microbial ecology. In particular, he is interested in new processes related to wastewater treatment and resource recovery. His research has resulted in several processes currently applied on full scale. He was awarded the Spinoza Award, Simon Stevin Award and the Singapore and Stockholm water prizes. He has published over 750 scientific papers, has 20 patents.

Willy Verstraete

Professor in Environmental Biotechnology at Ghent University

Willy Verstraete has a long record of accomplishment in Environmental Biotechnology as professor at the Ghent University. He particularly focuses on Microbial Resource Management in novel environmental processes. Since several years, he ranks as a 'highly cited author'. Throughout his career, he has developed technologies in the field of resource recovery that have reached full-scale implementation and market replication. He was founder of the cluster Resource Recovery from Water of the IWA. Recently he deals with upgrading resources to microbial protein and valuable biomass components, particularly in the context of the gasification of wastes and the upcoming hydrogen economy.

PLENARY PRESENTATION:

September 9th, h.09.00-09.30, Room Auditorium (audio-video connection to Room Theatre):
"20 YEARS OF BUSINESS IN RESOURCE RECOVERY FROM WATER"

Olaf van der Kolk

CEO of Aquaminerals

Olaf van der Kolk is the CEO of Aquaminerals, a non-profit organization representing all drinking water companies and water boards in the Netherlands. The mission of AquaMinerals is to provide services to its participants for the purpose of creating economic and sustainability value from the current and expected future resources that can be recovered from the watercycle. Currently, Aquaminerals has been successful in commercializing various residuals, recovered substances and even products recovered at drinking water and municipal wastewater treatment plants.

PLENARY PRESENTATION:

September 9th, h.14.30-15.00, Room Auditorium (audio-video connection to Room Theatre):
"SUSTAINABILITY ASSESSMENT FOR RESOURCE RECOVERY FROM WATER"

Jeremy S. Guest

Associate Professor at University of Illinois at Urbana-Champaign (UIUC)

Dr. Guest is an Associate Professor in the Dept. of Civil and Environmental Engineering at UIUC. His research focuses on the development of technologies for sustainable water, sanitation, and biofuels, with applications in both high- and low-income communities. His group collaborates with industry to advance algal processes for nutrient recovery from wastewaters, and develops sustainable design frameworks to prioritize research, development, and deployment pathways for emerging technologies for sanitation and resource recovery. He is the recipient of a National Science Foundation CAREER Award, the 2016 recipient of the Paul L. Busch Award for innovation in applied water quality research from the Water Research Foundation.

PLENARY PRESENTATION:
September 10th, h.09.00-09.30, Room Auditorium (audio-video connection to Room Theatre):
"ENHANCED METHANE RECOVERY AND APPLICATION IN WRRFS

Prof. Zhiguo Yuan AM

Director of the Advanced Water Management Centre at The University of Queensland

Prof. Yuan is the Director of the Advanced Water Management Centre at The University of Queensland. His research focuses on development of innovative solutions for urban water management through effective integration of fundamental science and applied engineering. His research areas include corrosion and odour management in sewers, resource recovery from wastewater and integrated urban water management. He has to date published about 400 fully refereed journal papers. His research achievements and leadership have been recognized through national and international awards, including the 2015 ATSE Clunies Ross Award and the International Water Association (IWA) 2014 Global Project Innovation Award.

PLENARY PRESENTATION:
September 10th, h.14.30-15.00, Room Auditorium (audio-video connection to Room Theatre):
"RESOURCE RECOVERY FROM WATER: OPPORTUNITIES FOR DEVELOPING COUNTRIES"

Miriam Otoo

Economist at the International Water Management Institute (IWMI)

Miriam Otoo is a senior economist leading the Resource Recovery and Reuse research group at IWMI, which has worked over 15 years on the interface of sanitation, waste (water), agriculture, health and environment. Her work aims at understanding the linkages between sanitation and agriculture to enhance food security via the analysis of business opportunities in the waste reuse sector in Africa, Asia and Latin America. To this, her research specifically focuses on the economics of carbon and nutrient recovery for agriculture, rural-urban food systems, and business solutions for waste management and resource recovery and reuse in developing countries.

PLENARY PRESENTATION:
September 11th, h.09.00-09.30, Room Auditorium (audio-video connection to Room Theatre):
"BRINGING WATER INNOVATION TO CIRCULAR ECONOMY MARKET"

Paul O'Callaghan

Founder and CEO of BlueTech Research

Paul O'Callaghan is the Founder and CEO of BlueTech Research, a global provider of water technology market intelligence. BlueTech provides actionable water market intelligence and helps water tech companies, corporate and utility end users, investors and research institutes to identify key trends and opportunities in the water industry. As a recognised industry expert with over 20 years of water experience, Paul has assisted companies of all levels in business development, acquisition strategy, market assessment, and identifying strategic opportunities.

Sunday, 8th September 2019

10:00 – 10:30	**Registration IWA RR 2019**		
10:30 – 13:30	**PRE-CONFERENCE WORKSHOP**		
	WORKSHOP 1 **TOWARDS CIRCULAR CITIES** *Chair: Günter Langergraber, COST Action CA17133 (A)* **Room Theatre**	**WORKSHOP 2** **EXPERIENCES WITH STRATEGY AND IMPLEMENTATION OF RESOURCE RECOVERY FROM WATER: CREATING (NEW) VALUE CHAINS AND ECONOMICS** *Chair: Olaf Van der Kolk, CEO Aquaminerals (NL);* *Ludwig Hermann, ESPP – IWA (D);* *Ilje Pikaar, University of Queensland (AUS)* **Room 6**	**WORKSHOP 3** **SUPER-W: RESOURCE RECOVERY FROM WASTEWATER: EMERGING TECHNOLOGIES & CONCEPTS** *Chair: Gijs Du Laing, Ghent University (B);* *Korneel Rabaey, Ghent University (B)* **Room Auditorium**
13:30 – 14:30	**Light lunch**		
14:30 – 15:30	**Young Water Professionals (YWP) MEET UP / ice-breaking event for YWP (Room 6)**		
15:00 – 16:30	**Registration IWA RR 2019**		
16:30 – 17:00	**Welcome speech by KEY ITALIAN WATER STAKEHOLDERS** (Room Auditorium - audio-video connection to Room Theatre)		
17:00 – 18:30	**CONFERENCE OPENING - PLENARY SESSION** Chairs: Francesco Fatone (IT) and Ilje Pikaar (AU) **THE ROLE OF RESOURCE RECOVERY FROM WATER WITHIN A CIRCULAR ECONOMY** Diane D'Arras, IWA President **RESOURCE RECOVERY IN EU FUNDED WATER PROJECTS** - Evdokia Achilleos, European Commission - EASME **PLENARY PRESENTATIONS** **RESOURCE RECOVERY FROM WATER: THE PAST, (success stories and lessons learned), THE PRESENT (current innovations), THE FUTURE (water 2050 and beyond – how will it look like?)** Mark Van Loosdrecht, TU Delft (NL) and Willy Verstraete, Ghent University (B) **IWA RESOURCE RECOVERY Award Ceremony**		
18:30	**Welcome cocktail – co-sponsored by ECOMONDO**		

Monday, 9th September 2019

8:00 – 9:00	**Registration IWA RR 2019**		
9:00 - 13:00	**MORNING SESSION**		
9:00 – 9:30	**PLENARY PRESENTATION** *Chair: Bruce Jefferson (United Kingdom)* **20 YEARS OF SUCCESFULL BUSINESS IN RESOURCE RECOVERY FROM WATER** Olaf Van Der Kolk, Aquaminerals (NL) (Room Auditorium - audio-video connection to Room Theatre)		
9:30 – 13:00	**SESSION 1** **NUTRIENTS RECOVERY AND REUSE** *Chairs: Bruce Jefferson, Isaac Owusu-Agyeman (YWP)* **Room Auditorium**	**SESSION 2** **PHOSPHORUS RECOVERY: NOVEL TECHNOLOGIES** *Chairs: Cees Buisman, Thomas Prot (YWP)* **Room 6**	**SESSION 3** **VALUE ADDED PRODUCTS AND BIOPOLYMERS RECOVERY** *Chairs: Mark van Loosdrecht, Ruizhe Pei (YWP)* **Room Theatre**
9:30 – 9:50	**KEYNOTE** **Water Reclamation and Nutrients Recovery Facilities in the Chinese Framework** Xia Huang, Tsinghua University (CN)	**KEYNOTE** **Biologically Induced Struvite Production in Wastewater** Ana Soares, Cranfield University (UK)	**KEYNOTE** **From Research to Full Scale Practice in Biopolymers Recovery** Rene Rozendal, PAQUES (NL)
09:50-11:05	**Building an Operational Framework for Nitrogen Recovery via Electrochemical Stripping** Matthew J. Liu, Boon Siong Neo, William A. Tarpeh	**Iron-reducing Biocathode for Phosphorus Remobilization from FeP Complexes Contained in Wastewater Sludge** Donya Sun, Xi Chen, Xiaoyuan Zhang, Peng Liang, Xia Huang	**Self-extinguishing Property of Biopolymers Recovered from Waste Aerobic Granular Sludge** Yuemei Lin, Kim Nam
10:05-10:20	**Nutrient Recovery from Wastewaters Using Novel Nano-enhanced Adsorptive Media** Ownby Miles, Ed Weinberg, Celine Vaneeckhaute	**Phosphorus Recovery from Sewage Sludge - P Leaching Behaviour from Various Types of Post-precipitated Tertiary Sludge** Marlena Monea, Volker Preyl, Carsten Meyer, Heidrun Steinmetz, Harald Schoenberger, Asya Drenkova-Tuhtan	**WWTP Biorefinery for Polyhydroxyalkanoates (PHAs) Recovery from Cellulosic Primary Sludge** Vincenzo Conca, Cinzia Da Ros, Nicola Frison, Anna Laura Eusebi, Francesco Fatone
10:20-10.35	**Enhanced Ammonia Recovery from Wastewater by Nafion Membrane with Highly Porous Honeycomb Nanostructure and Its Mechanism in Membrane Distillation** *Alicia An*	**Phosphorus Stripping of Bio-P Sludge and Enhanced Nutrient Recovery** *Blanca M. Gonzalez Silva, Dag B. Fiksdal, Chunbo He, Sveinung Sægrov, Stein W Østerhus*	**Producing Polyhydroxyalkanoates in HRAP Retrofitted for Wastewater Treatment with Phototrophic Purple Bacteria** *Joana Fradinho, Juliana Almeida, Estaban Serrano, Adrian Oehmen, Enrique Lara, Maria Reis*
10:35-10:50	**Tailored Polymer Hydrogels for Main-stream Ammonium Recovery from Domestic Wastewater** *Heidy Cruz, Jeremy Guest, Adrian Oehmen, Willy Verstraete, Bronwyn Laycock, Ilje Pikaar*	**Newly Developed Materials for Phosphorus Removal Recovery and Reuse in Decentralized Wastewater Treatment** *Solvei Jensen, Frances Helen Blaikie, Helmer Soehoel, Juan A. Alvarez, Hans Brix, Carlos Arias*	**An Urban Biorefinery for Food Waste and Biological Sludge Conversion into Polyhydroxyalkanoates and Biogas** *Giulia Moretto, Francesco Valentino, David Bolzonella, Paolo Pavan, Mauro Majone*
10:50-11:05	**Nitrogen Recovery from Process Water of Digested Sludge Dewatering with Membrane Contactors** *Lea Richter, Marc Wichern, Markus Grömping, Ulrich Robecke, Jens Haberkamp*	**Optimization of a Pilot Bioacidification Reactor to Increase the Potential for Recovery of Phosphorus from Municipal Wastewater Sludge** *Srdana Kolakovic, Jorge M.M. Santos, Maria A.M. Reis*	**Combined Wastewater Treatment and Bioflocculant Recovery** *Victor Ajao, Harry Bruning, Huub Rijnaarts, Hardy Temmink*

11:05-11:30	Morning coffee and presentation of EU projects concerning water and resource recovery (Room Grecale)		
11:30-13:00	*Chairs: Celine Vaneeckhaute, Sajid Hussain (YWP)* **Room Auditorium**	*Chairs: Giorgio Mannina, Saba Daneshgar (YWP)* **Room 6**	*Chairs: Rene Rozendal, Victor Ajao (YWP)* **Room Theatre**
11:30-11:45	**Nitrogen Recovery Using a Membrane Contactor: Modelling Nitrogen and pH Evolution** *Guillermo Noriega-Hevia, Joaquín Serralta, Luis Borrás, Aurora Seco, José Ferrer*	**Adsorption-Desorption Mechanism and Kinetic Study of Synthesized Iron Doped Zeolite for Phosphate in Aqueous Phase** *Md Saifuddin, Kwang Soo Kim*	**Rapid and Selective (Electro)catalytic Removal and Recovery of Sulfide from Wastewater** *Natalia Sergienko, Jelena Radjenovic*
11:45-12:00	**Nitrogen Up-concentration from Mainline and Sidestream Effluent in WWTPs for Fertilizer Valorization** *Álvaro Mayor Pillado, Silvia López Palau, Gabriel López Calvet, Lucía Prieto, Alicia Gadea, César Valderrama, Jose Luís Cortina, Irene Mozo Anibarro*	**Struvite Production by Using Raw Seawater - How to Improve the Economy and Keep the Product Quality?** *Sin Shaddel, Stein Østerhus*	**Sulfur Recovery in Biomethane Upgrading Plant** *Davide Ravezzani, Ottavia Burzi, Luca Pedrazzi, Davide Scaglione*
12:00-12:15	**Sustainable Ammonia Recovery from Source-separated Urine Using Isothermal Membrane Distillation** *Ngai Yi Yip*	**Role of Iron in Phosphorus Immobilization in a Novel VUCT-MBR System for Sewage Treatment** *Shaoyu Deng, Jingbao Tian, Jiaqi Liu, Lingyue Wang, Xiang Cheng*	**Salt and Humic Substances Recovery as A Solution to Anion Exchange Brine Management** *Elisabeth Vaudevire, Isaac Daniel*
12:15-12:30	**Resource Recovery from Wastewater: INCOVER Project** *Juan Alvarez, Christina Avila, Ana Pasqual, Rocio Pena, Santiago Gomez, Luz Herrero*	**Critical Conditions of Struvite Growth and Recovery Using Hydrocyclone in Novel Struvite Crystallization Pilot Plant** *Nari Park, Hyangyoun Chang, Yeoju Jang, Hyunman Lim, Jinhong Jung, Weonjae Kim*	**Critical Conditions of Struvite Growth and Recovery Using Hydrocyclone in Novel Struvite Crystallization Pilot Plant** *Nari Park, Hyangyoun Chang, Yeoju Jang, Hyunman Lim, Jinhong Jung, Weonjae Kim*
12:30-12:45	**Membrane-based Nitrogen Recovery from Livestock Wastewater: A Pilot Plant Study** *Beatriz Molinuevo-Salces, Berta Riaño, David Hernández, Matías B Vanotti, Mari Cruz García-González*	**Mathematical Model Application for Phosphorus Removal and Recovery Prediction in Continuous Flow Fixed-bed Columns** *Daniel Dias, João Ribeiro, Jorge Santos, Samuela Guida, Giorgia Rubertlli, Ana Soares, Adrian Oehmen*	**FAMEs Estolides and Methyl-10-Hydroxystearate: Sewage Sludge as Possible Source of Biodiesel and Bio-lubricants of New Generation** *Carlo Pastore, Luigi di Bitonto*
12:45-13:00	**Ammonium Recovery and Conversion Path by the Immobilization of Scenedesmus obliquus in Alginate Beads from Biogas Slurry** *Xiang Liu, Kaijun Wang, Jinyuan Ma*	**Cometabolic Production of Unusual Poly-β-Hydroxyalkanoates Using Enhanced Biological Phosphorus Removal Process in Sequencing Batch Reactors** *Chencheng Le, Li Wang, Yan Zhou*	**Cyrene™ as a New Bioderived Green Solvent for Membrane Preparation** *Alberto Figoli, Tiziana Marino, Antonio Molino, Francesca Russo, Francesco Galiano*
13:00-14:30	Lunch, poster presentation and lunch presentation of the European and Italian Sustainable Phosphorus Platform (Room Grecale)		

14:30-18:00	**AFTERNOON SESSION**		
14:30-15:00	**PLENARY PRESENTATION** *Chair: Ana Soares (United Kingdom)* **SUSTAINABILITY ASSESSMENT FOR RESOURCE RECOVERY FROM WATER** Jeremy Guest, University of Illinois at Urbana-Champaign (USA) (Room Auditorium - audio-video connection to Room Theatre)		
15:00-18:00	**SESSION 4** **NUTRIENTS RECOVERY AND REUSE** *Chairs: Ana Soares, William Tarpeh (YWP)* **Room Auditorium**	**SESSION 5** **PHOSPHORUS RECOVERY: PILOT, DEMO AND FULL-SCALE TECHNOLOGIES** *Chairs: Julian Sandino, Claydon Mumba Kanyunge (YWP)* **Room 6**	**SESSION 6** **ECONOMIC AND ENVIRONMENTAL SUSTAINABILITY ASSESSMENT** *Chairs: Jeremy Guest, Antoine Brison (YWP)* **Room Theatre**
15:00-15:20	**Nutrient Upcycling from Wastewater Treatment: Technical and Non-Technical Roadmap** *Maria Albuquergue, Celine Bouchereau, Erik Bundgaard, Marisa Cunha, Ana Bisinella, Bruno Tisserand*	**KEYNOTE** **Self-sustaining Sludge Smouldering: Towards On-Site Complete Sludge Destruction and P Recovery** *Jose Torero, University College (UK)*	**Life Cycle Assessment of Material Recovery from Municipal Wastewater: Circular Economy with Environmental Benefits?** *Christian Remy, Jennifer Misiukas, Carlijn Lahaye, Zivco Jucnic-Zonta, Juan Baeza, Nicola Frison, Bruno Ferreira, Gorostegi Guerra, Sergio Salas, Joan Jorda, Luis Enriques*
15:20-15:35	**High-solid Thermophilic Anaerobic Digestion with Ammonia and Phosphate Recovery** *Masanobu Takashima, Junichi Yaguchi*	**Ash2Phos -- Clean Commercial Products from Sludge Ash** *Yariv Cohen, John Svärd*	**Environmental and Economic Assessment of Solar-assisted Thermal Energy Recovery from Wastewater** *Ivan Muñoz, Francisco Portillo, Sabina Rosiek, Javier Francisco, Iñaki Acasuso, Valentina Piergrossi, Marco Disanctis, Silvia Chimienti, Claudio Di Iaconi*
15:35-15:50	**Pilot Scale Studies on Nutrient and Biochar Recovery from Wastewater and Sewage Sludge** *Laura Rossi, Aino Kainulainen*	**4 Years of Phosphorus Recovery at WWTP Amsterdam West** *Alex Veltman, Jacquelien de Schutter*	**Life Cycle Assessment of Nutrient Recovery from Wastewater - Current Practices and Insights** *Ka Leung Lam, Ljiljana Zlatanović, Jan Peter van der Hoek*
15:50-16:05	**Fractionating Various Nutrient Ions for Phosphate Recovery from Swine Wastewater Using Selective Electrodialysis** *Zhi-Long Ye, Boudewijn Meeschaert, Shaoho Chen, Karel Ghyselbrecht, Xin Ye, Annick Monballiu, Luc Pinoy*	**Thermochemical P-Recovery from Sewage Sludge Ash** *Schaaf Tanja, Ulbrich Julian, Orth Andreas*	**The Economics Behind the Combination of AnMBR and FO Technologies for Municipal Wastewater Treatment** *Sergi Vinardell, Sergi Astals, Joan Mata-Álvarez, Joan Dosta*
16:05-16:30	**Afternoon coffee and presentation of WAREG – European Water Regulators – Andrea Guerrini (President)** **(Room Grecale)**		

16:30-18:00	*Chairs: Claudio Di Iaconi, Cinzia Da Ros (YWP)* **Room Auditorium**	*Chairs: Ludwig Hermann, Alessia Foglia (YWP)* **Room Theatre**	*Chairs: Olaf van der Kolk, Giulia Cipolletta (YWP)* **Room 6**
16:30-16:45	**Optimised Nutrient Recovery from Biogas Digestate by Solid/liquid Separation and Membrane Treatment** *Sandra Rosenberger*	**The Inhibitory Effects of Free Nitrous Acid and Free Ammonia on the Aerobic Phosphorous Utilization Rate** *Dimitris Andreadakis, Constantinos Noutsopoulos, Gerasimos Ragkiskatos, Kyriaki Argyropoulou, Theodora V. Missirli, Daniel Mamais, Simos Malamis*	**Circular Economy in Water Sector and Italian Regulation Activities** *Andrea Guerrini*
16:45-17:00	**Nutrient Recovery from the Perspective of the Flemish Wastewater Utility** *Bart Saerens, Francis Meerburg, Marjoleine Weemaes*	**Phosphorus and Ammonia Removal and Recovery through Ion Exchange (IEX) Process at Demonstration Scale** *Samuela Guida, Georgia Rubertelli, Bruce Jefferson, Ana Soares*	**Novel Financing Strategies to Simultaneously Advance Sanitation and Agriculture Through Nutrient Recovery** *Hannah Lohman, John Trimmer, David Katende, Muwonge Mubasira, Maria Nagirinya, Fred Nsereko, Noble Banadda, Jeremy Guest*
17:00-17:15	**Reusable Magnetic Sorbent Materials for Advanced Wastewater Treatment and Nutrient Recovery** *Asya Drenkova-Tuhtan, Carsten Meyer, Caleb Inskeep, Karl Mandel, Thomas Ballweg, Michael Schneider, Carsten Gellermann, Heidrun Steinmetz*	**Chemical vs. Biological Phosphorus Removal: Full-scale Process Optimisation for Resources Saving** *Laura Menoni, Gergio Bertanza, Roberta Pedrazanni*	**Integration of Statistical Monitoring and Life Cycle Assessment to Evaluate the Sustainability Behavior of WWTPs** *Peyo Stanchev, Vasileia Vasilaki, Francesco Fatone, Evina Katsou*
17:15-17.30	**Hydrothermal Carbonization (HTC) for the Nutrient and Energy Recovery from Digested Sewage Sludge** *Anna Hämäläinen, Jukka Rintalla, Marika Kokko, Viljami Kinnunen, Tuomo Hilli*	**Mainstream SCEPPHAR Configuration for Integrating P and PHA Recovery in the Water Line of WWTPs** *Oriol Larriba, Zivko Juznic-Zonta, Borja Solis, Juan Baeza, Albert Guisasola*	**Evaluation and Cost-efficiency of On-site Wastewater Reuse Systems** *Darja Istenič, Nataša Atanasova, Aleksandra Krivograd Klemenčič, Franja Prosenc, Tjasa Griessler Bulc*
17:30-17:45	**High Efficiency Phosphorus Recovery and Sewage Sludge Valorization via Hydrothermal Carbonization** *Gianni Andreottola, Maurizio Volpe, Luisa Mariafioti, Luca Fiori*	**Boosting the P Extraction from the Sludge by Rearranging the Sludge Line in a WWTP** *Ramón Barat, Miguel Roldán, José Ferrer, Nuria Martí, Teresa Alvariño, Francisco Javier Navarro*	**Life Cycle Assessment and Cost-Benefit Analysis of a Multi-Step Process of Olive Mill Wastewater Valorization through Polyphenol Adsorption and Anaerobic Digestion** *Dario Frascari, Tjerk Wandenaar, Emmanuel Oertlè, Atef Jaouani, Davide Pinelli*
17:45-18:00	**Simultaneous Nitrogen Removal and Phosphorous Recovery in Anoxic and Microaerobic Biofilm Systems** *Francesco Di Capua, Francesca Iannacone, Francesco Granata, Rudy Gargano, Francesco Pirozzi, Giovanni Esposito*	**Phosphorus Recovery and Management in Alto Trevigiano Servizi: From Pioneer Struvite Recovery to Current Regional Strategies** *Alberto Piasentin, Luca Girotto, Matteo Tartini, Roberto Durigon, Pierpaolo Florian*	**Measuring the Circularity Potential of an Eco-friendly Touristic Facility in a Mediterranean Island** *Chrysanthi-Elisabeth Nika, Peyo Stanchev, Evina Katsou*
Evening	**Young (and "not so Young") Water Professional event (San Servolo garden)**		

Tuesday, 10th September 2019

9:00-13:00	MORNING SESSION		
9:00-9:30	**PLENARY PRESENTATION** *Chair: Korneel Rabaey (Belgium)* **ENHANCED METHANE RECOVERY AND APPLICATION IN WRRFS** Zighuo Yuan, University of Queensland (AUS) (Room Auditorium - audio-video connection to Room Theatre)		
9:30-13:00	**SESSION 7** **URINE VALORIZATION AND WATER REUSE** *Chairs: Korneel Rabaey, Prithvi Simha (YWP)* **Room Theatre**	**SESSION 8** **PHOSPHORUS RECOVERY: NOVEL TECHNOLOGIES** *Chairs: Siegfried E. Vlaeminck, Çağrı Akyol (YWP)* **Room Auditorium**	**SESSION 9** **VALUE ADDED PRODUCTS AND BIOPOLYMERS RECOVERY** *Chairs: Lars Angenent, Juan Castilla-Archilla (YWP)* **Room 6**
9:30-9:50	**KEYNOTE** **The Beneficiation of Urine and Faecal Fractions from Urine-Diversion Double-Vault Toilets (UDDTs) in Ethekwini Municipality South Africa** *Sudhir Pillay, Water Research Commission (SA)*	**KEYNOTE** **Enhanced Anaerobic Treatment as Core of the WRRFs: Pilot and Full Scale Experiences** *Bruce Jefferson, Cranfield University (UK)*	**KEYNOTE** **Cellulose Recovery and Carbon Upgrading by Integrating Microsieving and Fermentation Technologies in Wastewater Treatment Plants: A Plant-Wide Modeling Study** *Santoro Domenico, Trojan Technologies (CA)*
9:50-10:05	**Achieving Nutrient Resource Efficiency through Urine Separation Processing and Reuse: A Comprehensive Study** *Nancy Love, Glen Daigger*	**Efficient Utilization of Regional Biomass with Intensive Digestion System Using Sludge Solubilisation and Solid Oxide Fuel Cell** *Manabu Matsuhashi, Ryoichi Maeda, Haruo Miyake, Yusuke Shiratori, Atsushi Tajima*	**Volatile Fatty Acids Production: Effect of Bacterial Community under Various Operational Conditions** *Merve Atasoy, Zeynep Cetecioglu Gurol*
10:05-10:20	**Safe Production of Microbial Protein from Urine** *Mark Dodds, Yifeng Zhang, Elena Toressi, Monika Skadborg, Barth F. Smets, Borja Perez Valverde*	**Innovative Ex-situ Biological Biogas Upgrading Using Immobilized Biomethanation Bioreactor (IBBR)** *Katie Baransi-Karkab, Mahdi Hassanen, Sharihan Muhsein, Nidal Massalha, Isam Sabbah*	**Targeting Specific Volatile Fatty Acid Production through pH Shifts During Protein Fermentation** *Riccardo Bevilacqua, Alberte Regueira, Miguel Mauricio-Iglesias, Marta Carballa, Juan M. Lema*
10:20-10:35	**Green Walls Optimized for Treatment and Reuse of Greywater** *Fabio Masi, Alice Caruso, Elisa Magna, Silvia Fiore, Francesca Demichelis, Ana Galvao, Janoa Pisoeiro, Anacleto Rizzo, Luca Ridolfi, Fulvio Boano*	**High Rate Immobilized Anaerobic System Treating Wastewater - Evaluation and Simulation at a Pilot-scale System** *Isam Sabbah, Daniel Dias, Jorge Ribeiro, Mahdi Hassanin, Morad Massalha, Jorge Santos, Nedal Massalha, Salva Shmulevich, Avi Aharoni, Adrian Oehmen*	**Biorefinery Pilot Plant for VFAs and Nutrients Recovery from Agro-waste Material** *Simone Nortilli, Edoardo Rigetti, Nicola Frison, David Bolzonella*
10:35-10:50	**Improvement of Water Quality Through BAC Filtration in a Water Reclamation Plant** *Laura Palli, Stefano Fiaschi, Michelle Allocca, Vittoria Viviani, Claudio Lubello, Riccardo Gori, Roberto Camissa, Donetella Fibbi*	**Free Nitrous Acid Pre-treatment of Waste Activated Sludge Enhances Efficiency and Rheological Behaviour of Anaerobic Sludge Digester** *Jia Meng, Huijuan Li, Shoan Shrestha, Min Zheng, Haoran Duan, Jason Dwyer, Shihu Hu, Zhiguo Yuan*	**Pilot Scale Acidogenic Fermentation of Microsieved Cellulosic Sludge for Short Chain Fatty Acids Production** *Cinzia Da Ros, Nicolas Frison, Vincenzo Conca, Anna Laura Eusebi, Francesco Fatone*
10:50-11:05	**Removal of Micropollutants from Wastewater by Rapeseed Simultaneous Biosorption** *Irina Morosanu, Carmen Teodosiu, Daniela Fighir, Carmen Paduraru*	**Long Term Operation of Anaerobic Municipal Wastewater Treatment of Low-loaded Wastewater for Fertigation Purposes** *Alessia Foglia, Çağrı Akyol, Anna Laura Eusebi, Giulia Cipolletta, Nicola Frison, Stefania Gorbi, Francesco Fatone*	**Direct Membrane Filtration of Municipal Wastewater by Ceramic Flat-sheet Membranes for Recovery of Organic Matter** *Katsuki Kimura, Megumi Kato*
11:05-11:30	**Morning coffee and pitch of EU projects concerning water and resource recovery (Room Grecale)**		

11:30-13:00	*Chairs: Glen Daigger, Miriam Otoo* **Room Theatre**	*Chairs: Isam Sabbah, E. Gozde Ozbayram (YWP)* **Room Auditorium**	*Chairs: Peter Vale, Angel Estevez Alonso (YWP)* **Room 6**
11:30-11:45	**Evaluation of Design Wastewater Treatment Plant Tertiary Process for Water Reuse with the Application of Modelling Tool** *Paolo Cirello, Giancarlo Cecchini, Mario de Mola, Emilia Bernardini, Barbara Biagi*	**Non-ideal Mixing Model of Anaerobic Digestion: Linking the CFD Model and ADM1** *Yohannis Mitiku Tobo, Jan Bartacek, Ingmar Nopens*	**Hydrothermal Carbonization of Sewage Sludge: Process Optimization by Response Surface Methodology** *Monica Puccini, Andrea Tasca, Gemma Mannarino, Anna Raspolli Galletti, Sandra Vitolo, Ricardo Gori*
11:45-12:00	**An Integrated Wastewastewater Management Approach to Increase Wastewater Reuse in Mediterranean Regions** *Giuseppe Mancini, Antonella Luciano, Paolo Viotti, Debora Fino*	**Exploring Forward Osmosis for Production of Reclaimed Water and Concentrated Wastewater for Anaerobic Treatment** *Federico Ferrari, Ignasi Rodriguez-Roda, Maijte Puijan, Gaetan Blandin*	**Pretreatment and Process Optimization for Brewery Spent Grain Conversion into Chemical Building Blocks** *Juan Castilla-Archilla, Stefano Papirio, Piet N.L. Lens*
12:00-12:15	**Recovery of Ammonia from Urine with an Open-loop Hollow Fiber Membrane Contactor** *Junhui Zhang, Mengfei Xie, Haoxiang Yu, Dan Qu*	**Long-term Performance of Two Pilot Scale Anaerobic Reactors for Thermal Hydrolyzed Sludge Digestion under Mesophilic and Thermophilic Conditions** *Zhan Chen, Wei Li, Jiawei Wang, Xianghua Wen*	**Selective Separation of Organics and Inorganics by Ion-Exchange Membranes** *Lingshan Ma, Leonardo Guiterez, Muhammad Waqas, Emile Cornelissen, Marjolein Vanoppen, Arne Verliefde*
12:15-12:30	**Application of Membrane Distillation for Optimal Fertilizer Recovery from Human Urine** *Mekdimu Damtie, Federico Volpin, Minwei Yao, Leonard Tijing, Yun-Chul Woo, June-Seok Choi, Ho-Kyong Shon*	**Intensifying Energy Recovery via Biological in situ Biogas Upgrading by Means of Hydrogenotrophic Methanogenesis in WWTP** *Viola Corbellini, Francesca Malpei*	**Pathogen Inactivation and Resource Recovery from Sanitation Waste Through In-situ Accumulation of Carboxylic Acids** *Lauren Harroff, Janice Liotta, Dwight Bowman, Largus Angenent*
12:30-12:45	**Urine Dehydration Technology for Recycling Nutrients in a Public Dry Sanitation System** *Prithvi Simha, Jenna Senecal, Caroline Karlsson, Riikka Malila, Eeva Liisa Viskari, Björn Vinnerås*	**Full-scale Anaerobic Co-digestion of Sludge and Organic Waste: Rovereto Four-year Experience** *Cristina Cavinato, Filomena Ardolino, Giovanni Gatti, Gian Paolo Mattuzzi, Franco Cecchi*	**Impact of Advanced Separation Technologies on the Fermentation Products of Municipal Sludge** *Antoine Brison, Nicolas Derlon*
12:45-13:00	**Enabling Resource Recovery by In-Sewer Treatment and Microbial Ecology-based Engineering: Water Re-Use Starts Now in the Sewer** *Nouha Klai, Lisha Guo, Domenico Santoro, Dominic Frigon*	**Blend Quality and Logistics Optimization of Anaerobic Codigestion in a Real Multi-Plant Case Study** *David Palma, Marta Verdaguer, Manel Poch, M.À. Cugueró-Escofet*	**Anaerobic Co-digestion of Sewage Sludge and External Organic Waste: Strategy to Shift Production from Biogas to Volatile Fatty Acids** *Isaac Owusu-Agyeman, Ezbieta Plaza, Zeynep Cetecioglu Gurol*
13:00-14:30	**Lunch, poster presentation and WATER EUROPE speech concerning "Water oriented Living Labs" Andrea Rubini (Water Europe) "Developing soft skills as core strategy to secure and speed up water related innovation in industries and utilities" Anita D'Agnolo Valla (InnoSuccess) (Room Grecale)**		

14:30-18:00	AFTERNOON SESSION		
14:30-15:00	**PLENARY PRESENTATION** *Chair: Guenter Langergraber,(Austria)* **RESOURCE RECOVERY FROM WATER: OPPORTUNITIES FOR DEVELOPING COUNTRIES** Miriam Otoo, International Water Management Institute (LK) (Room Auditorium - audio-video connection to Room Theatre)		
15:00-18:00	**SESSION 10** **BIOPOLYMERS AND VALUE-ADDED PRODUCTS RECOVERY: NOVEL TECHNOLOGIES** *Chairs: Mauro Majone, Vincenzo Conca (YWP)* **Room Theatre**	**SESSION 11** **ECONOMIC AND ENVIRONMENTAL SUSTAINABILITY ASSESSMENT** *Chairs: Ger Bergkamp, Giuseppe Mancini* **Room 6**	**SESSION 12** **ROAD TO BIOREFINERY AND WRRF IMPLEMENTATION** *Chairs: Guenter Langergraber, Emel Topuz (YWP* **Room Auditorium**
15:00-15:20	**Valorisation of Complex Wastewater for the Production of PHA** *Alba Roibás-Rozas, Lucia Argiz, Alba Predouso, Angeles Val Del Rio, Almudena de Hospido, Anuska Corral Mosquera*	**Evaluating Construction Industry Views on Recovered Cellulose as a Component of Building Materials** *Elaine Gallagher, Caitriona Shannon, Heather Smith*	**KEYNOTE** **Full Scale Biorefinery and Territorial Strategy for Resource Recovery and Reuse: The Case of CAP Holding Italy** *Andrea Lanuzza, CTO, CAP Holding (I)*
15:20-15:35	**Recovery of ALE (Alginate-like Exopolymer) from Aerobic Granular Sludge and Application as Phosphorus Adsorbent** *Patricia Dall´Agnol, Nelson Libardi, Jessica Xavier, Rejane Helena Ribeiro Da Costa*	**The Sustainability of Microbial Protein as Feed Ingredient - A Comparative Life Cycle Assessment of Three Growth Metabolisms with Soybean Meal** *Marc Spiller, Maarten Muys, Myrsini Sakarika, Gustavo Papini, Matthias Buyle, Siegfried E. Vlaeminck*	**Compounds of Interest in Wastewater from Food Processing Industries: H2020 AFTERLIFE Project** *Andrea Martos Dominguez, Santiago Perez Rodriguez, Nicola Frison, Maria Lopez Abelairas*
15:35-15:50	**Optimization of a PHA Production Process with Nitrifying Surplus Activated Sludge via Dissolved Oxygen Control** *Angel Estevez-Alonso, Ruizhe Pei, Robbert Kleerebezem, Mark van Loosdrecht*	**From Waste to Self-healing Concrete: A New Value Chain for Polyhydroxyalkanoates** *Chris Vermeer, Emanuele Rossi, Robbert Kleerebezem, Henk Jonkers, Jelmer Tamis*	**CoRe Water: From WWTP to a Sustainable Water and Resource Factory** *Kees Roest, Julian Sierra Muñoz, Lex van Dijk, Annie Polman, Hans Ramaekers, Alexander Hendriks, Emile Cornelisen*
15:50-16:05	**Influence of Wastewater Composition and Bioaggregates Types on the Properties of Alginate-like Exopolymers** *Cássio Moraes Schambeck, Lukas Boni, Peter Fischer, Elisabeth Girbal-Neuhauser, Yolaine Bessière, Paul Etienne, Rejane Helena Ribeiro da Costa, Nicolas Derlon*	**Cost of Sericin Recovery from Silk Effluents** *Tolga Pilevneli, Merve Gencturk, Ulku Yetis, Goksen Capar*	**Chemically Enhanced Primary Treatment: Shall We Pay More Attention to Bio-sourced Coagulants to Maximize CH4 Production?** *Florent Chazarenc, Fatima Ezzahraa El Messaoud*
16:05-16:30	**Afternoon coffee and pitch of EU projects concerning water and resource recovery (Room Grecale)**		

	Chairs: Cristina Cavinato, Nicola Frison (YWP) **Room Theatre**	*Chairs: Vanessa Parravicini, Matia Mainardis (YWP)* **Room 6**	*Chairs: Anna Laura Eusebi, Christian Remy* **Room Auditorium**
16:30-16:45	**Biopolymers Recovered from Waste Anammox Granular Sludge as Paper-Coating Additives to Enhance Water and Grease Resistance** *Cuijie Feng, Tommaso Lotti, Francesca Malpei*	**Integrated Sustainability Assessment of Wastewater Treatment Plants as Local Energy Suppliers** *Peter Lichtenwoehrer, Florian Kretschmer, Guenter Langergraber, Georg Neugebauer*	**Water Recovery and Reuse, Between Opportunities and Barriers: The Integrated Fusina Project (PIF)** *Patrizia Ragazzo, Cristiano Franzoi, Andrea Razzini*
16:45-17:00	**Extraction and Characterisation of Polyhydroxybutyrate Biologically Synthesised Using Mixed Microbial Cultures** *Dario Presti, Gabriella Montiel-Jarillo, Diego Morales-Urrea, Giorgio Mannina, Edgardo Contreras, Julián Carrera, María Eugenia Suárez Ojeda*	**Developing a Market Place for Water in the Circular Economy: The NextGen Approach** *Christos Makropoulos*	**Enabling Next Generation Resource Recovery** *Julian Sandino, Samuel Jeyanayagam*
17:00-17:15	**Impact of Influent Suspended Solids on Granulation and Production of Gel-forming Polymers in an Aerobic Granular Sludge Reactor Treating Brewery Wastewater** *Flinn De Vleeschauwer, Michel Caluwe, Jan Dries*	**Comparative Cost Estimations of Full-scale Phosphorus-recovery Processes in German Wastewater Treatment Plants** *Lea Conzelmann, Fabian Kraus, Christian Remy*	**Upgrading of a Wastewater Treatment Plant to Resource Recovery** *Dines Thornberg, Nick Ahrensberg, Jeanette Agertved*
17:15-17:30	**Extracellular Polymeric Substances (EPS) from Anammox Granular Sludge as Biosorbent for Heavy Metals Removal** *Benedetta Pagliaccia, Tomasso Lotti, Emiliano Caretti, Mirko Severi, Deborah Berti, Claudio Lubello*	**Thermal Energy Recovery Within Sewage Treatment Process** *Marco De Sanctis, Valentina Piergrossi, Guido Valerio Altieri, Sabina Rosiek, Francisco Portillo, Francisco Javier Battles, Javier Martinez Del Rio, Iñaki Acasuso, Claudio Di Iaconi*	**Using Monte Carlo Based Simulation Optimization for the Design and Optimization of Wastewater Resource Recovery Facilities** *Resul Al, Chitta Ranjan Behera, Gürkan Sin*
17:30-17:45	**Exploring Resource Recovery Potentials for the Aerobic Granular Sludge Treatment Process** *Philipp Kehrein, Mark van Loosdrecht, Patricia Osseweijer, Jo de Wulf, Marianna Garfi, John Duque Posada*	**Drinking Water Distribution Networks: An Emerging Resource for Thermal Energy Recovery** *Jawairia Imtiaz Ahmad, Sara Giorgi, Ljiljana Zlatanovic, Gang Liu, Gertjan Medema, Jan Peter Van Der Hoek*	**Hydrothermal Carbonization as a Suitable Process for Resource Recovery and Enhancement of Biogas Production from Sewage Sludge** *Gemma Mannarino, Monica Puccini, Andrea Salimbeni, Massimo Aiello, Simone Caffaz, Riccardo Gori*
17:45-18:00	**Recovery Potentials from Aerobic Granular Sludge Treating Low C/N Real Municipal Wastewater** *Riccardo Campo, Emiliano Carretti, Debora Berti, Simone Caffaz, Claudio Lubello, Tomasso Lotti*	**Waste-to-Resource Transformation – Computer-aided Systems Modelling of Waste Resource Recovery** *Miao Guo*	**Micro-sieving of Municipal Wastewater Improves Effluent Quality Energy Balance and Clarification Capacity of WWTPs** *Nicolas Derlon, Ken Lüding, Markus Behl, Benno Maissen, Tobias Krast, Simone Buetzer, Alexandra Fumasoli*
Evening	**GALA DINNER** **At Hotel Excelsior Venice Lido Resort at 20.00**		

Wednesday, 11th September 2019

9:00-11:00	MORNING SESSION		
9:00 – 9:30	**PLENARY PRESENTATION** *Chair: Willy Verstraete (Belgium)* **BRINGING WATER INNOVATION TO CIRCULAR ECONOMY MARKET** Paul O'callaghan, BlueTech Research (IRL) (Room Auditorium - audio-video connection to Room Theatre)		
9:30 – 11:00	**SESSION 13** **SMART PLANT SESSION** *Chairs: Francesco Fatone, Evina Katsou* **Room Theatre**	**SESSION 14** **PROTEIN AND VALUE-ADDED PRODUCTS RECOVERY: NOVEL TECHNOLOGIES** *Chairs: Willy Verstraete, Ilje Pikaar* **Room Auditorium**	**SESSION 15** **GOVERNANCE AND REGULATION** *Chairs: Kees Roest, Heather Smith* **Room 6**
9:30 – 09:50	**Recovery and Valorisation of Cellulose from Wastewater - The Road to Circularity** *Pim Marcellis, Coos Wessels, Carlijn Lahaye*	**KEYNOTE** **Polymer Grade Succinic Acid Production from Organic Waste:** **The PERCAL Project Pipeline** *Korneel Rabaey, Ghent University (B)*	**KEYNOTE** **Barriers and Opportunities for a Circular Economy of Phosphorus in the Baltic Sea Region** *Karina Barquet, Stockholm Environment Institute (S)*
09:50-10:05	**Exploring the Integration of EBPR at Low SRT and DO in an A-stage System for COD and P Removal** *Claudio Scalia, Congcong Zhang, Giorgio Mannina, Albert Guisasola, Juan Baeza*	**Purple Phototrophic Bacteria - Biofilm Technology for Microbial Protein Production** *Tim Hulsen, Samuel Stegman, Paul Jensen, Damien Batstone*	**The Politics of a Transition Towards a Circular Economy in the Dutch Wastewater System** *Kasper Ampe, Erik Paredis, Lotte Asveld, Patricia Osseweijer, Thomas Block*
10:05-10:20	**Nitrogen Removal via Nitrite from Thermally Hydrolysed and Digested Reject Water** *Evangelos Statiris, Constantinos Noutsopoulos, Daniel Mamais, Nikolaos Petalas, Simos Malamis*	**Economic Potential of Brewery Effluent Treatment with Maximized Heterotrophic Microbial Protein Production** *Gustavo Papini Gomes de Sousa, Maarten Muys, Marc Spiller, Francis Meerburg, Siegfried Vlaeminck*	**Economic Potential of Brewery Effluent Treatment with Maximized Heterotrophic Microbial Protein Production** *Gustavo Papini Gomes de Sousa, Maarten Muys, Marc Spiller, Francis Meerburg, Siegfried Vlaeminck*
10:20-10:35	**Modelling of a Novel Side-stream Technology Combining Short-cut Nitrogen Removal and Bioplastic Recovery** *João Ribeiro, Vincenzo Conca, Jorge Santos, Daniel Dias, Nilay Sayi-Ucar, Cinzia Da Ros, Adrian Oehmen*	**Power-to-Protein: Next Step Towards Consumable Single Cell Proteins from Waste Water and Renewable Hydrogen** *Frank Oesterholt, Luc Palmen, Willy Verstraete, Jos Boere*	**Time to Stop Flushing Potable Water with Our Faeces & Urine - A National Water Strategy Based on Resource Recovery from Re-Engineered Toilets** *Jayan Bhagwan, Valerie Naidoo, Sudhir Pillay*
10:35-10:50	**Trade-offs Between Environmental and Operational Parameters in SCENA Process** *Vasileia Vasilaki, Vincenzo Conca, Nicola Frison, Francesco Fatone, Evina Katsou*	**Biological Upgrading of Biogas and Production of Single Cell Proteins** *Jeanette Madsen, Jacob Kragh Andersen, Nick Ahrensberg, Panagiotis Tsapekos*	**Impact and Opportunities for the Urban Water Cycle of the 'Fully Circular in 2050' Target of the Netherlands - Circular Water 2050** *Kees Roest, Laura Snip, Luc Palmen, Ben Römgens, Andrew Sergrave, Henk-Jan Alphen*
10:50-11:05	**Environmental Technology Verification of the Full-Scale Short-Cut Enhanced Nutrients Abatement (SCENA) Process** *Vincenzo Conca, Nicola Frison, Cinzia Da Ros, Matteo Tartini, Alberto Piasentin, Anna Laura Eusebi, Francesco Fatone*	**Towards More Sustainable Food Chain: Microbial Protein Production from Catalytically of Biologically Fixed CO2** *Myrsini Sakarika, Pieter Candry, Ramon Ganiguè, Korneel Rabaey*	**Decentralised Water and Waste Treatment in View of Resource Recovery** *Stijn Van Hulle*
11:05 – 11:30	**Morning coffee and presentation of the EU PRIMA Initiative (Room Grecale)**		

11:30 – 13:00	**SESSION 16** **METALS RECOVERY** *Chairs: Juan Antonio Baeza, Giovanni Esposito* **Room 6**	**SESSION 17** **MICROALGAE-BASED PROCESSES** *Chairs: Tim Hulsen, Alice Botturi (YWP)* **Room Theatre**	**SESSION 18** **HIGH VALUE CHEMICALS/MATERIALS RECOVERY** *Chairs: Simos Malamis, David Bolzonella* **Room Auditorium**
11:30 – 11:45	**Membrane Electrolysis for Separation of Cobalt from Terephthalic Acid in Industrial Wastewater** *Rui Gao, Xochitl Dominguez-Benetton, Jeet Varia, Bernd Mees, Gijs, Du Laing, Korneel, Rabaey*	**Application of Microalgae for Wastewater Treatment and Recovery of Bioenergy and High-value Bioproducts** *Larissa Arashiro, Ivet Ferrer, Diederik P.L. Rousseau, Stijn W.H.Van Hulle, Marianna Garfi*	**Photoelectrocatalytic Production of Hydrogen and Commodity Chemicals from Desalination Brine** *Linchao Mu, William A. Tarpeh*
11:45 – 12:00	**Detection Removal and Recovery of Metals from Water Sludge and Fly Ash** *Kees Roest, Edwin Buijzer, Luc Palmen, Julian Muńoz Sierra*	**Recovery and Recycling of Nutrients from Wastewater with Algae** *Maja Berden Zrimec, Ana Cerar, Borut Lazar, Matej Slapnik, Lara Resman, Rok Mihelič, Robert Reinhardt*	**Production of N-caproate from Food Waste Without pH Control: Consecutive Lactate Formation and Chain Elongation** *Carlos Contreras Davila, Cees Buisman, David Strik*
12:00 – 12:15	**Towards Lithium Selective Membranes: Crownether Containing Poly-Electrolyte Multilayer Membranes** *Mohammad Kazemabad, Arne Verliefde, Emile R. Cornelissen, Arnout D'Haese*	**Integration of Microalgae Culturing as a Side-stream Process into Wastewater Treatment Plants: An LCA Evaluation** *Lucia Rigamonti, Camilla Tua, Elena Ficara*	**A Potential P Fertilizer – Biochar Produced by EBPR Sludge** *Tingting Qian, Yan Zhou*
12:15 -12:30	**An Integrated Approach for HCl and Metals Recovery from Waste Pickling Solutions: Pilot Plant Design and Operations** *Rosa Gueccia, Daniel Winter, Serena Randazzo, Andrea Cipollina, Giorgio Domenico Micale, Joachim Koschikowski, Florian Gross*	**Use of Microalgae Grown on Fish Tank Residual Nutrients as Feed for Copepods to Enable Circular Bio-economy in Aquaculture** *Borja Valverde Pérez, Lars A. Ahrens, Anette M. Christensen, Carlos O. Letelier-Gordo*	**Advanced Composting and Bio-drying as an Opportunity to Recover Material and Energetic Resources from Sludges** *Nagore Guerra, Mabel Mora, Lara Pelaz, Jonatan Ovejero, Laia Llenas, Belèn Puyuelo, Joan Colón, Sergio Ponsá*
12:30 – 13:00	**OFFICIAL CLOSING of the conference** **(concluding remarks organizing committee + award for YWPs best poster and/or presentation)** **(Room Auditorium - audio-video connection to Room Theatre)**		
13:00 – 13:45	**Presentations and voting for the next conference**		
13:15 – 14:00	**Light Lunch (reserved for participants in post-conference workshop)**		
14:00 – 18:00	**POST CONFERENCE WORKSHOPS**		
	WORKSHOP 1 **6TH MIXED CULTURE PHA WORKSHOP – DAY 1** *Chairs: Mauro Majone, La Sapienza University of Rome (I); Alan Werker, Wetsus (NL)* **Università Ca' Foscari, Venice** ** See detailed Program pag. 44*	**WORKSHOP 2** **H2020 WATER INNOVATIONS FOR SUSTAINABLE IMPACT IN INDUSTRIES AND UTILITIES** *Chairs: H2020 projects SMART-Plant (Francesco Fatone), HYDROUSA (Simos Malamis), NextGen (Jos Frijns / Christos Makropoulos), Project-O (Ilaria Schiavi) – co-organized by European Commission - EASME (Evdokia Achilleos)* **San Servolo - Room Theatre**	

Thursday, 12th September 2019

9:00 - 17:00	TECHNICAL VISITS TO FUSINA TREATMENT PLANT AND RESOURCE RECOVERY SITES IN TREVISO PROVINCE
9:00 - 12:00	Technical Visit 1 – Fusina (co-organized and supported by water utility VERITAS SpA)
12:00 -13:00	Lunch Break
14:00 -17:00	Technical Visit 2 – Treviso Province (co-organized and supported by with water utility Alto Trevigiano Servizi srl)

YOUNG WATER PROFESSIONAL MEET-UP

YOUNG WATER PROFESSIONALS

the international water association

In order to promote active participation and interactions among fellow YWPs and pave connections with senior professional during the event, the YWP Organizing Committee has:

- Dedicated a designated area where the YWPs can meet, relax and exchange ideas – YWP Corner;
- Chosen YWPs to co-chair the conference sessions together with their senior colleagues;
- Reward the best platform and poster presentations done by YWPs. Please note that all presentations done by PhD students or younger than 35 years old are automatically included in the nomination for the award.

Last but not least, along with exceptional conference sessions, the YWP Organizing Committee invites you to participate to two extra-conference events, especially organized for our YWP colleagues:

- Ice-breaking Workshop, September 8th, 2019, h. 14.30-15.30, Room 6. San Servolo Island, which aims to ice-break among YWPs and get to know each other before the conference.
- YWP Social Event, September 9th, 2019, h. 18.30-21.30 Cocktail party in San Servolo garden, then “Bacari tour” around the most typical bars in Venice.

PRE-CONFERENCE WORKSHOPS

PRE-conference Workshop 1
Towards Circular Cities

Organised by the COST Action CA17133 Circular City

September 8th, h.10.30 -13:30 Room Theatre, San Servolo Island, Venice
Chairs: Guenter LANGERGRABER, Chair of the COST Action Circular City; Natasa ATANASOVA, Co-Chair of the COST Action Circular City

The COST Action Circular City (https://circular-city.eu/) aims to establish a network testing the hypothesis that: "A circular flow system that implements NBS for managing nutrients and resources within the urban biosphere will lead to a resilient, sustainable and healthy urban environment".
Expert representing the five Working Groups, i.e. Built environment, Urban Water, Resource Recovery, Urban farming and Transformation tools (connecting the WGs and the socio-economic impact) will present the state-of-the-art and will elaborate the way forward towards Circular Cities.

Program

10:00	Registration
10:30	Welcome and introduction to the COST Action Circular City
10:45	Presentation of the state-of-the-art (highlights from review papers prepared by the Actions WG's
11:30	Q&A
11:45	Coffee break
12:00	Discussion on beneficial and hindering factors for implementing nature-based solutions and circular economy in cities (discussions in 4 groups, world cafe style) • 15 min discussions at each table • 15 min summary from tables
13.20	Summary and closure
13.30	End of the workshop

Target participants:

Water professionals, researchers, utilities, technology providers, policy makers, consultants, and market players and industries outside the water sector able to implement these new concepts.

PRE-conference Workshop 2

Experiences with strategy and implementation of Resource Recovery from Water: Creating new value chains and economics

September 8th, h.10.30 -13:30 Room 6, San Servolo Island, Venice

Chairs: Olaf van der Kolk, Aquaminerals; Ludwig Herman, ESPP-IWA; Ilje Pikaar, University of Queensland

This workshop includes:

- Presentations by forerunners in the field of RR from water in which they will share their experiences: successes, failures, critical success factors.
- Concrete cases will be shared that underpin these critical success factors. Universal hurdles will be discussed, as well as the possible solutions to overcome these. Discussion with panel of experts with a strong focus on the viewpoints of the end-user / consumer and the regulator in relation with (but not limited too) water & energy, water reuse, nutrients recovery, organics recovery, C-footprint and integration in the water tariff.
- The attendees are challenged to come up with 'challenging' cases from their own work field (at least 2 weeks before the session). These cases will be discussed in the second part of the workshop, where the input of all attendees is welcomed.

Program

10:00	Registration
10:30	Welcome and introduction to workshop. Explanation of the program
10:45	Presentations by forerunners in the field of RR from water where they will share their experiences: successes, failures, critical success factors. Ludwig Hermann and Olaf van der Kolk will elaborate on some real life case studies / value chains: from idea to practice (… or failure). Martijn Olde Weghuis from the Dutch drinking water company Vitens will explain how they managed to implement their ambitious strategy leading to the successful recovery and use of a variety of materials.
11.45	Coffee break
12:00	Discussion on: 1. Where and how do you start? 2. Who are your partners and how do you set up (and maintain) a fruitful cooperation?
13.20	Summary and closure
13.30	End of the workshop

Target participants:

Utilities, water professionals, technology providers, service providers, policy makers, consultants, scientists as well as market segments and industries outside of the water sector that can valorize the recovered resources.

PRE-conference Workshop 3
SuPER-W: Resource Recovery from wastewater: emerging technologies & concepts

Organised by the Marie Curie ITN project No 676070 SuPER-W (closing event)

September 8th, h.10.30 -13:30 Room Auditorium, San Servolo Island, Venice
Chairs: Chairs: Gijs du Laing, Ghent University; Korneel Rabaey, Ghent University

Achievements of the 4-year Marie Curie ITN project SuPER-W on Sustainable Product, Energy and Resource Recovery from Wastewater (https://www.superw.ugent.be/). • SuPER-W showcases of 14 joint doctoral candidates in the field of RR from wastewater, sharing their experiences (results, successes, and failures). • A "future challenges" workshop café. Attendees are challenged to reflect in ad-hoc thematic groups. Outcomes are presented to the attendees in a plenary closing session.

Program

10:00	Registration
10:30	SuPER-W overview (Gijs du Laing)
10.40	(Flash) Presentations by the doctoral candidates
11.10	Non-technical bottlenecks for the implementation of resource recovery technologies into WWTPs (Philipp Kehrein)
11.25	Explanation of cases and objectives of the "future challenges" workshop café (Korneel Rabaey)
11:45	Coffee break
12.00	"Future challenges" workshop: group work
13.00	"Future challenges" workshop: group presentations and discussion round
13.30	End of the workshop

Target participants:

Stakeholders involved in resource recovery (e.g., researchers, utilities, water professionals, technology providers, service providers, policy makers, consultants)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skodowska-Curie grant agreement No 676070

POST-CONFERENCE WORKSHOPS

POST-conference Workshop 1
6th mixed Culture Pha WorkShop

Co-organised by H2020 projects RES URBIS, SCALIBUR, SMART-Plant

Venue
Università Ca' Foscari, Venice - Room Mario Baratto

Projects are supported with Horizon 2020 European Union Funding for Research & Innovation

September 11th-12th, Room Mario Baratto (Università Ca' Foscari, Venice)
Chairs: Alan Werker, Wetsus; Mauro Majone, La Sapienza, Francesco Valentino, La Sapienza

Program

DAY 1 _September 11th, h.12.00-19.00 Room Mario Baratto (Università Ca' Foscari, Venice)

12:00	Arrival of registered participants
12.30	Lunch buffet
13.45	Welcome
13.50	RESURBIS
14.20	Technical session I
16.30	Light break
17.00	Technical session II
19.00	Closing remarks

DAY 2_ September 12th Conference – h.09.00-16.00, Room Mario Baratto (Università Ca' Foscari, Venice) and Site Visits, h.16.00-20.30, Carbonera and Treviso pilot plants

08.45	Arrival of registered participants
09.10	Welcome
09.15	SMART-Plant
09.40	Technical session III
11.30	Light break
12.30	Technical session IV
14.15	Closing remarks
14.30	Walk and talk to Tronchetto Terminal
16.30	Bus leaves for Technical visits
19.30	Return bus ride to Tronchetto Terminal

Target participants:

Researchers, technology providers, innovative entrepreneurs and industries

POST-conference Workshop 2
H2020 Water Innovations for sustainable impacts in industries and utilities

Co-organized by H2020 projects SMART-Plant, HYDROUSA, NextGen, Project-O and European Commission - EASME

September 11th, h.14.15 -18.15 Room Theatre, San Servolo Island, Venice
Chairs: Evdokia Achilleos, EC-EASME, Francesco Fatone, H2020 SMART-Plant, Simos Malamis, H2020 HYDROUSA, Jos Frijns, H2020 NextGen, Ilaria Schiavi, H2020 Project-O

Advanced **Horizon 2020 water projects (IAs)** resulting from the Societal Challenge "Climate Action, Environment, Resource Efficiency, and Raw Materials" (years 2015 to 2017) will pitch their water circular economy solutions to clients (utilities / industries) and stakeholders (e.g. regulators). A panel of selected representative clients /stakeholders will interact and provide feedback to participants. A breakout session is foreseen to discuss opportunities and challenges in the market uptake of the proposed circular economy solutions.

Program

14.00 Registration

14.15 Welcome speech by Evdokia Achilleos – European Commission - EASME

14.40 **Pitching session**
Pitching water innovations and circular economy solutions. A representative panel of utilities and stakeholders will ask questions and provide feedback at the end of each session

Panel 1: Pitch presentations by H2020 projects INCOVER, SMART-Plant, RUN4LIFE, SALTGAE and ZEROBRINE.
Panelists from: EurEau, Water Alliance – NL, CAP Holding , VERITAS , UTILITALIA/UTILITATIS, SUEZ, Severn Trent Water

Panel 2: Pitch presentations by H2020 projects NextGen, HYDROUSA; Project-O, Water 2Re-turn, DWC.
Panelists from: WATER EUROPE, Aqua Publica Europea , Alto Trevigiano Servizi, HERA, SMAT, VEOLIA, Socamex

15.50 Q&A from audience Introduction to breakout session

16.00 Introduction to breakout session

16.10 Coffee break

16.30 **Breakout session**
5 thematic areas:
1. Water & Energy (Moderators: SMART-Plant and EurEau)
2. Water Reuse (Moderators: Project-O and Water Europe)
3. Nutrient Recovery and Recycling (Moderators: RUN4LIFE and ESPP)
4. Bio-based Resource Recovery and Recycling (Moderators: nextGen and Water Alliance NL)
5. Carbon and ecological footprint integration in the water tariff (Moderators: HYDROUSA and Aqua Publica Europea)

17.40 Debriefing and points for policy and regulation brief (5 minutes per topic)

18.05 Closing, (and award if voting in pitching)

18.15 End of the workshop

Target participants:

- Utilities, researchers, water professionals, technology providers, policy makers, as well as market segments and industries outside of the water sector that can valorize the recovered resources.
- Key Associations such as EurEau, Aqua Publica Europea and WAREG and other water utilities and authorities' associations
- Representatives from key EU initiatives: Water Europe, ESPP, EIP Water, EIP Agri, SPIRE PPP, EIT Climate-KIC, Raw Materials-KIC, Circular Economy Finance Platform, InnovFin, European Assistance for Innovation procurement (EAFIP))

PITCH / LUNCH PRESENTATIONS

ESPP - European Sustainable Phosphorus Platform
phosphorusplatform.eu
Lunch presentation: September 9th, h.13.45-14.00, Grecale Room

Italian Sustainable Phosphorus Platform
www.minambiente.it/pagina/piattaforma-italiana-del-fosforo
Lunch presentation: September 9th, h.14.00-14.15, Grecale Room

WAREG
European Water Regulators Andrea Guerrini (President)
www.wareg.org
Speech by Andrea Guerrini (President): September 9th, h.16.05-16.30, Grecale Room

EU projects concerning water and resource recovery
Pitch presentations:
September 9th, h.11.05-11.30, Grecale Room
September 10th, h.11.05-11.30, Grecale Room
September 10th, h.16.05-16.30, Grecale Room

WATER EUROPE – Technology and Innovation
http://watereurope.eu/
Lunch presentation by Andrea Rubini: September 10th, 13.00-14.30, Grecale Room
"Water oriented Living Labs" Andrea Rubini (Water Europe) "Developing soft skills as core strategy to secure and speed up water related innovation in industries and utilities" Anita D'Agnolo Vallan (InnoSuccess)

EU PRIMA Program is the The Partnership for Research and Innovation in the Mediterranean Area
http://prima-med.org/
Pitch presentation: September 11th, h.11.05-11.30, Grecale Room

COMMUNICATION

Media Partner ECOMONDO

Ecomondo, www.ecomondo.com - the leading event in Europe for the new models of circular economy, is supporting IWA RR 2019 media partner.

Interviews and media coverage by RICICLA TV

RICICLA TV, the online editor specialized in Environmental topics will support IWA RR 2019 with video sessions and interviews to the main speakers and stakeholders.
Videos will be published in thewebsite www.riciclа.tv and RICICLA TV social networks.
Links will be available at in the conference website www.iwarr2019.org .

PHOTOGRAPHY and VIDEO DISCLAIMER
The conference organisers have arranged for professional video and photography onsite throughout the conference. The images may be used for post-conference reports, case studies, marketing collateral and supplied to industry media if requested. If you do not wish for your photo to be taken, please inform a staff member at the Registration Desk.

TECHNICAL VISITS

TECHNICAL VISIT TO FUSINA TREATMENT PLANT

(co-organized and supported by water utility VERITAS SpA)

September 12th, 2019, h.09.00-12.00

Gruppo VERITAS

Gruppo Veritas is a public multi-utility, the first in Veneto by size and turnover and one of the largest in Italy: eighth for integrated water services and sixth for environmental ones.

The "Integrated Project Fusina" (PIF) was conceived as a response to the need to carry out operations treat and reuse wastewater.

The project involves the construction of an "Integrated Multifunctional Plant" at Fusina, creating a multi-functional platform for the treatment and purification of industrial water, polluted groundwater, first rainfall and deriving from the reclamation work in the Porto Marghera area, through chemical processes -physical followed by natural treatment in "Cassa di Colmata A". Furthermore, municipal waste water, once treated up to reuse quality, is returned for industrial uses to the cooling plants of the production activities located within the Site of National Interest of Venice - Porto Marghera.

The "Fusina Integrated Project" aims to provide answers to the problems of lagoon pollution and environmental protection through:

- the reduction of pollutants in the area of the Site of National Interest of Venice - Porto Marghera thanks to the treatment of industrial wastewater and to the post-treatment of municipal wastewater;
- the reclamation of polluted sites in Porto Marghera, in the regeneration of water resources and in the redevelopment of the "Cassa di Colmata A" and the "Vallone Moranzani" landfill.

The "PIF" plant is connected to the open sea by a submerged pipe 160 cm in diameter for about 20 km that, starting from Fusina, crosses the Venice Lagoon and the Venice Lido and delivers to the open sea, to a distance of 10 km from the coast and a depth of -20 meters. Offshore discharge of water that is not reused minimizes the impact on the delicate ecosystem of the Venetian Lagoon.

TECHNICAL VISIT TO RESOURCE RECOVERY SITES IN TREVISO AND CARBONERA

(co-organized and supported by water utility Alto Trevigiano Servizi SpA)

September 12th, 2019, h.14.00-17.00

ATS – Alto Trevigiano Servizi
Water utility of Treviso Province (Italy) co-organizing and supporting the technical visit to resource recovery sites in Treviso province

Alto Trevigiano Servizi srl
Alto Trevigiano Servizi srl (ATS) is a public-owned water utility that manages urban water cycle services (drinking water production and distribution, sewers systems and wastewater treatment) of 52 municipalities in Veneto region, North-East of Italy. ATS serves about 500,000 inhabitants and it manages 64 WWTPs, about 1600 km sewers systems, 152 sewage pumping stations, 183 supply sources, about 4,800 km drinking water distribution systems and 86 drinking water pumping stations.

Treviso Resource Recovery site
Treviso WWTP was started-up in 1970s to serve the municipality of Treviso. The initial configuration had a treatment potential of 30,000 PE increased to 70,000 PE in 2000 years.
The biological reactor treats the sewage water through the Biological Nitrogen Removal Process in one line and, through intermittent aeration, in the second one. Anaerobic codigestion of excess sludge with the liquid organic fraction of municipal solid waste is performed since 2000 years. The biogas production is now valorized with microturbines, installed in 2019, by producing 195 kWe and 224 kWt. The self-produced energy is 100% consumed in the WWTP (a charging electric car station was recently installed in order to power supply the new cars of the Water Utility). In the plant is located one of the first demonstration area to recovery struvite from the anaerobic supernatants from urban wastewater.

Carbonera Wastewater Treatment Plant
Carbonera WWTP is located in Treviso Province, with maximum capacity of 40,000 PE. The biological process applies Simultaneous Nitrification and Denitrification process in circular reactor. Primary and secondary sludges are valorised with anaerobic digestion and with recent installation of microturbines. Moreover, in the plant are located two of the innovative solutions developed in SMART-Plant H2020 project (SMARTech 4a and 5). The SMARTech 4a is the first full scale application of Short Cut Enhanced Nutrients Abatement (SCENA). The Short Cut Enhanced Phosphorus and PHA Recovery- SCEPPHAR (SMARTech 5) is pilot scale that is aiming to the integration of conventional biogas recovery from cellulosic primary sludge with the energy-efficient nitrogen removal via-nitrite from sludge reject water and the recovery of PHA and struvite.

TECHNICAL VISIT TO FUSINA TREATMENT PLANT
from 9.00 to 12.00

TECHNICAL VISIT TO RESOURCE RECOVERY SITES IN TREVISO AND CARBONERA
from 14.00 to 17.00
Rate: € 30,00 per person

The rate includes travel and lunch.

A ferryboat transfer will be available from San Servolo Island at 8.30 (pick up time at 8.20). Return is expected to Venice – Piazzale Roma at 18.30.
Participants registered for the Visits will find their ticket in the Conference Kit.
Please hold your ticket and show it to the Conference Staff to access the Technical visits and transfer services.
No admission is allowed without ticket.

With 90,000 employees across five continents, SUEZ is a global leader in smart, sustainable resource management. The Group provides solutions for managing water and waste that help cities and industries optimise the management of their resources and improve their environmental and economic performance while complying with current regulations.

SUEZ has been present in Italy for more than 50 years in the field of design, build and management of municipal and industrial water treatment plants and has successfully built in the country more than 700 facilities both in the civil and industrial sectors.

www.suez.com

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SMART-Plant FINAL EVENT

The 3rd IWA resource recovery conference hosts the SMART-Plant final event. The H2020 project SMART-Plant "Scale-up of low-carbon footprint material recovery techniques in existing wastewater treatment plants" is in fact on of the main organisers of the conference.

Project Information

Since June 2016, SMART-Plant has been working to scale up and demonstrate eco-innovative and energy-efficient solutions in order to upgrade existing wastewater treatment plants. Nine low-carbon footprint processes are being applied to wastewater treatment plants in Greece, Spain, Italy, the Netherlands, the United Kingdom and Israel. These processes are demonstrating how biogas, cellulose, phosphorus and polyhydroxyalkanoates (PHA) bioplastics can be recovered and processed to generate industrial and commercial end products. The aim is to optimise wastewater treatment, resource recovery and energy efficiency while also reducing greenhouse gas emissions.
Materials recovered from the innovative technological processes used at the six wastewater treatment plants are currently being tested to find potential commercial applications. SMART-Plant also seeks to detect potential harmful compounds such as antibiotics, pesticides, hormones and heavy metals. Through field experiments, the project also tests the fertilising effect of phosphorous on cultures in order to demonstrate its ability to improve soil quality. Demonstrated technologies, together with recovered substances themselves, are therefore stepping significantly closer to market.

SMART-Plant Coordinator:
Francesco Fatone – Università Politecnica delle Marche
For more information:
Website: http://www.smart-plant.eu
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Twitter: https://twitter.com/smart_plant_eu
Phone: +39 071 2204911

SMART-Plant Final event @IWARR2019

September 8th-11th, h.09.00-18.00 – SMART-Plant stand and SMARTechs and SMART-products exhibition, Atrio Colonne, 1st floor
September 11th h.9.30 – 11.00 SMART-Plant Session, room Theatre, 1st floor
September 11th , h. 14.30- 18.30 Post-conference workshop co-organized with EASME and H2020 projects HYDROUSA, NextGen, Project-O, room Theatre, 1st floor
September 12th, h.14.00-17.00 Technical visit to Carbonera pilot plants (SMARTechs 4a and 5)

SOCIAL PROGRAM and EXCURSION

SUNDAY, SEPTEMBER 8, 2019 AT 18.30

WELCOME COCKTAIL
At San Servolo Island – Venice

SPONSORED BY

ECOMONDO

(included in the registration fee)

MONDAY, SEPTEMBER 9, 2019 AT 18.30

YOUNG WATER PROFESSIONALS SOCIAL EVENT
At San Servolo Island – Venice

(included in the registration fee of Young Water Professional and Students)
Please note that the ticket you found in the envelope must be shown to the staff.

TUESDAY, SEPTEMBER 10, 2019 AT 20.00

GALA DINNER
At Hotel Excelsior Venice Lido Resort

Lungomare Marconi, 31 - Venice Lido
Rate € 75,00 per person

Participants registered for the gala dinner will find their ticket in the Conference Kit.
Please hold your ticket and show it to the Conference Staff to access the dinner venue and transfer services.
No admission is allowed without ticket.
Tickets for Gala Dinner can be purchased (only) by Credit Card at the Registration Desk and the Social Program Desk by September 9 at 13.00.

A transfer service will be available from San Zaccaria / M.V.E. “B” Pick up and San Servolo Pick up as follows:
San Zaccaria 19.10
San Servolo 19.25
The return is scheduled at 23.00.

VISIT AND EXCURSION

DISCOVERING MURANO & BURANO

Discover the two main islands around Venice: Murano and Burano. You will be enchanted by the glass masterpieces of Murano Companies and by the Burano bright colourful houses. A professional and local assistant will lead you at the discover of these islands, suggesting the best places to visit as soon as you get off from the private boat, which bring you to the various places.

EXPLORING ST. ERASMO ISLAND

In the middle of the Venetian lagoon, a world away from the hustle and bustle of Venice,there is an island called the garden of Venice: St Erasmo. Narrow canals, field, vineyards..everything makes this island a unique place where relax and have a different kind of experience in the lagoon.

ART, WINE AND FOOD IN VENICE

In this unique experience, you will have the opportunity to discover two different, but equally important sides of the city of Venice: art and gastronomy. You can choose between three different cultural itineraries in the historic centre: the Doge's Palace and St. Mark's Basilica, the Guggenheim Collection, or the Scuola of San Rocco and the Scuola of San Giovanni Evangelista.

THE ARTISANS OF VENICE

You will see before your very eyes their skilled hands and their refined tools for carving wood or for giving shape to gold, manipulating papier-mâché or even turning hot liquid glass into a solid master piece. You will share with your beloved ones these precious moments that will enrich your visit and help you to get to know Venice off the beaten track.

BACARO TOUR

Included in the registration fee for accompanying persons – registration required.
Discover the traditional venetian gastronomy, known all over the world for its fresh fish and its savory wine. This tour will give you the opportunity to discover the street food of Venice: you will stop by three different "bacari" (traditional taverns), where you will taste the traditional "cicchetti" (appetizers) and a glass of wine. Your local tour guide will lead you in the authentic and genuine atmosphere that characterizes the Rialto Bridge. You will feel like a true Venetian during the happy hour in Venice.

DISCOVERING ST. MARK SQUARE

Included in the registration fee for accompanying persons – registration required.
"The most beautiful leaving room of Europe" as Napoleon defined it. Let a professional tour guide lead you in the heart of Venice. Your experience will start with explanations about the extraordinary buildings of St. Mark's square, like Palazzo Ducale, the residence of the Doge of Venice, the supreme authority of the former Republic of Venice. After that, you will discover the stunning St. Mark Basilica, the cathedral church of the Roman Catholic Archdiocese of Venice.

PRESENTATIONS ABSTRACTS

Session 1
NUTRIENTS RECOVERY AND REUSE
Room Auditorium

Water Reclamation and Nutrients Recovery Facilities in the Chinese Framework
Xia Huang

Water and nutrients shortage is increasing worldwide. For relieving the problem, water reclamation and phosphorous recovery were carried out in China. For water reclamation, the average wastewater reuse rate in China is still lower, in which membrane technology is increasingly developed due to its appealing advantages. For phosphorous recovery, there was only a few attempts in China.

Building an Operational Framework for Nitrogen Recovery via Electrochemical Stripping
Matthew Liu, Boon Siong Neo, William Tarpeh

Electrochemical stripping has recently been demonstrated to selectively recover over 90% of ammonia nitrogen from varying wastewater influents. To accelerate this process toward implementation, we combined modelling and experiments to identify impacts of rate-limiting steps. Ammonia volatilisation in the cathode was determined to play a central role in limiting nitrogen recovery; we explored effects of catholyte temperature, influent concentration, and gas permeable membrane choice on nitrogen recovery, removal, operation times. We constructed and validated a mass transfer model to predict energy requirements for varying operating parameters to help prioritize strategies that accelerate rates of nitrogen recovery from wastewater.

Nutrient Recovery from Wastewaters Using Novel Nano-enhanced Adsorptive Media
Ownby Miles, Ed Weinberg, Celine Vaneeckhaute

Current nutrient recovery practices for phosphorus (P) from wastewaters result in low-grade, slow-release, land applied fertilizer. Residual dissolved nutrients not captured are harmful in the environment and act as biocatalysts contributing to the ever-increasing frequency of harmful algae blooms. RD&D efforts demonstrate that commercially available nano-enhanced media, a new class of adsorbents, offer immediate relief to pollutant nutrient overloads in impaired watersheds. One such media, hybrid ion exchange resin (HIX-Nano) has been used to remove naturally occurring arsenic from drinking water, and can remove soluble reactive P from agricultural wastewaters. The nano-enhanced media are regenerable, and customized regeneration chemistry can result in liquid N-P-K fertilizer and non-fertilizer products with greater market value compared to recycled P products such as struvite.

Enhanced Ammonia Recovery from Wastewater by Nafion Membrane with Highly Porous Honeycomb Nanostructure and Its Mechanism in Membrane Distillation
Alicia An

Nitrogen removal in wastewater by conventional treatment methods requires substantial energy, only to release it back to the atmosphere as gaseous nitrogen. Herein, we investigated the applicability of membrane distillation (MD) in treating sludge digestate to recover resource by controlling the volatility and pressure of the vapor transport across the membrane to concentrate ammonia in the permeate stream. A mixture of Nafion ionomer and Multiwall Carbon Nanotubes (MWCNTs) was incorporated into a Poly(vinylidene fluoride-co-hexafluoropropene; PVDF-HFP) nanofiber matrix to fabricate a honeycomb-nanoporous Nafion membrane that has high recovery and increased mechanical strength. This study demonstrated an innovative and realistically applicable MD treatment process that allows for resource recovery with low-grade heat integration and has scaling-up potential for wastewater treatment plants.

Tailored Polymer Hydrogels for Main-stream Ammonium Recovery from Domestic Wastewater

Heidy Cruz, Jeremy Guest, Adrian Oehmen, Willy Verstraete, Bronwyn Laycock, Ilje Pikaar

A key challenge for urban water management is how to re-envision its role within the circular economy will be to develop technologies that enable main-stream ammonium recovery. In this paper, a new pathway is proposed that allows for mainstream ammonium recovery based on physico-chemical sorption using polymer hydrogels. Our results show that this adsorption-based approach holds potential for high-rate mainstream continuous adsorption coupled with side-stream recovery of ammonium with minimal chemical requirements. Modified polymer hydrogels achieved final effluent concentrations of 10.1 ± 0.12 to 18.3 ± 0.53 mg/L NH4-N in real sewage at a contact time of ~10 minutes. At this effluent concentrations, simulation results show that allowable discharge concentrations (<10 mg/L) can be achieved after biological assimilation of the residual nitrogen from the mainstream sorption process.

Nitrogen Recovery from Process Water of Digested Sludge Dewatering with Membrane Contactors

Lea Richter, Marc Wichern, Markus Grömping, Ulrich Robecke, Jens Haberkamp

Membrane contactors are expected to be an attractive alternative to other physicochemical and biological sidestream treatment processes for removing and recovering nitrogen from process water deriving from digested sludge dewatering. Münster wastewater treatment plant (WWTP) is the first German WWTP to implement a full-scale membrane contactor treatment with the objective to improve the nitrogen elimination and recovery efficiency. Within the scope of this investigation, influences on the operation and membrane performance are studied. First results confirm a high nitrogen removal efficiency of > 95 % and the production of marketable ammonium sulphate solution.

Nitrogen Recovery Using a Membrane Contactor: Modelling Nitrogen and pH Evolution

Guillermo Noriega-Hevia, Joaquín Serralta, Luis Borrás, Aurora Seco, José Ferrer

Membrane contactor has been applied for nitrogen recovery from anaerobic digestion supernatant. The results obtained show that the recovery efficiency depends on the pH of the nitrogen-rich stream. Complete nitrogen recovery was achieved at pH values over 9 but at pH values below 8.6, the process is stopped A mathematical model was developed in order to represent the evolution of pH and nitrogen concentration during the recovery process. The model developed shows a good accuracy for describing the evolution of pH and nitrogen concentration in the different experiments carried out.

Nitrogen Up-concentration from Mainline and Sidestream Effluent in WWTPs for Fertilizer Valorization

Álvaro Mayor Pillado, Silvia López Palau,Gabriel López Calvet, Lucía Prieto, Alicia Gadea, César Valderrama, Jose Luís Cortina, Irene Mozo Anibarro

Nowadays, nitrogen (N) is removed through nitrification-denitrification (N/DN) process in conventional Waste Water Treatment Plants (WWTPs). Energy demand for air supply and the associated emissions of CO2 (direct and indirect) and N2O (direct) could be reduced by implementing alternative technologies for N concentration i.e. zeolites and valorising the ammonium recovered as fertilizer. It has been estimated that a medium size conventional WWTP (130,050 PE) presents a carbon footprint of 0.14 kg CO2/m3 at a cost of 1€/kg N removed. The same WWTP with a zeolites based system for N recovery would have a carbon footprint of -0.06 kg CO2/m3 and up to now at a relatively higher cost, 1-4 €/kg N recovered. More research is needed to ensure both sustainability and viability of such a solution. This study assess the technical and economic viability of activated clinoptilolite (natural zeolites) applied to three different streams in a WWTP: mainline effluent (50 mg NH4+-N/L), centrate sidestream (1000 mg NH4+-N /L) and a tertiary effluent (5 mg NH4+-N /L).

Sustainable Ammonia Recovery from Source-separated Urine Using Isothermal Membrane Distillation

Ngai Yi Yip

The recovery of water from human urine has gained a lot of interest to reduce increasing water demand. Sustainable ammonia recovery from source-separated urine using isothermal membrane distillation became more and more challenging.

Resource Recovery from Wastewater: INCOVER Project

Juan Alvarez, Christina Avila, Ana Pasqual, Rocio Pena, Santiago Gomez, Luz Herrero

INCOVER project has been designed to move wastewater treatment from being primarily a sanitation technology towards a bio-product recovery industry and a recycled water supplier. Three added-value case studies treating wastewater have been implemented, assessed and optimised concurrently. INCOVER case studies are implemented at demonstration scale in order to ensure straightforward up scaling to 100,000 PE. INCOVER technologies will generate benefits from wastewater offering three recovery solutions: 1) Chemical recovery (bio-plastic and organic acids) via algae/bacteria and yeast biotechnology; 2) Near-zero-energy plant providing upgraded bio-methane via pre-treatment and anaerobic co-digestion systems; 3) Bio-production and reclaimed water via adsorption, biotechnology based on wetlands systems and hydrothermal carbonisation.

Membrane-based Nitrogen Recovery from Livestock Wastewater: A Pilot Plant Study

Beatriz Molinuevo-Salces, Berta Riaño, David Hernández, Matías B Vanotti, Mari Cruz García-González

Gas-permeable membrane technology that recovers ammonia nitrogen from livestock wastewater was tested at pilot scale in a swine farm. The technology recovered up to 38 g ammonia nitrogen per m2 of membrane per day. However, wastewater temperature greatly affected the rate of recovery. The technology not only contributes to reduce ammonia emissions but also recovers nutrients in the form of an ammonium salt, which could be used as fertilizer.

Ammonium Recovery and Conversion Path by the Immobilization of Scenedesmus obliquus in Alginate Beads from Biogas Slurry

Xian Liu, Kaijun Wang, Ma Jinyuan

Microalgae growth coupling biogas slurry treatment was viewed as a promising strategy to produce biomass. In order to cell harvesting, microalgae was immobilized in alginate bead matrix and the relevant parameters were optimized by the response surface methodology (RSM). The results showed that the maximal mean removal efficiencies of 86.35±1.83%, 96.57±0.12% and 65.16±4.45% for ammonium (NH4+-N) after 5 days of cultivation applied at three NH4+-N initial concentrations (30, 50 and 70 mg/L). Compared to the free-living microalgae system, immobilized microalgae had greater ability to treat biogas slurry with high concentration of NH4+-N. Assimilation was the principal conversion path with the production of glutamate and proline. These results will provide a theoretical foundation for the recycling handles of biogas slurry.

Session 2
PHOSPHORUS RECOVERY: NOVEL TECHNOLOGIES

Room 6

Biologically Induced Struvite Production in Wastewater

Ana Soares, Cranfield University (UK)

Biologically induced mineral formation can be exploited to recover phosphorus from liquid streams and wastewater through struvite production. Selected microorganisms were able to grow in wastewater and remove up to 91% ortho-phosphate. B. antiquum removed ortho-phosphate from initial concentrations of 5.4 mg/L to ≤1 mg/L. Biological struvite (bio-struvite) (identified by morphological, XRD and elemental analysis) could be isolated as a salt when the wastewater contained ≥19.7 mg ortho-phosphate/L, compared with ≥62.4 mg ortho-phosphate/L for abiotic struvite precipitation after pH adjustment. The bio-struvite recovered presented high purity and contained low heavy metal contents, which enable the bio-struvite to meet proposed regulations for inorganic fertilizers. Overall, bio-struvite production presented important advantages, in comparison with abiotic struvite, and the process should be further developed for implementation at pilot and full scale.

Iron-reducing Biocathode for Phosphorus Remobilization from FeP Complexes Contained in Wastewater Sludge

Donya Sun, Xi Chen, Xiaoyuan Zhang, Peng Liang, Xia Huang

Phosphorus remobilizing from the wastewater sludge produced in chemical phosphorus removal process is a key challenge for nutrient resource recovery in future wastewater treatment plants (WWTPs). In this study, the proof-of-concept of an electrical potential induced iron-reducing biocathode is demonstrated, aiming to reduce Fe3+ and release PO43- from the FeP complexes contained in the wastewater sludge. Compared with non-potential applied biocathode, the PO43- release efficiency could be improved by more than 45% in the iron-reducing biocathode. The kinetic equation of Fe3+ reduction in iron-reducing biocathode could be expressed as: dα/dt=k^' (1-α) ^(2/3)The cyclic voltammetry (CV) curves and microbial community analysis indicated that the applied potential could benefit the electron transfer during the Fe3+ reducing process.

Phosphorus Recovery from Sewage Sludge - P Leaching Behaviour from Various Types of Post-precipitated Tertiary Sludge

Marlena Monea, Volker Preyl, Carsten Meyer, Heidrun Steinmetz, Harald Schoenberger, Asya Drenkova-Tuhtan

Phosphorus (P) is an essential element for life and a key nutrient for agriculture and global food security. However, P resources are finite and this is one of the most important reasons to think about P-recovery from secondary sources. Most of the studies so far looked at the P recovery potentials from anaerobically digested sludge or activated sludge. Tertiary sludge has not been the focus of the studies yet. In this work Al and Fe-containing tertiary sludges from different sewage treatment plants were investigated in terms of their P leaching potential. The dissolution rate of P but also of Al and Fe was systematically investigated in the acidic and alkaline pH range. All experimental results were compared against data obtained from the leaching of anaerobically digested sewage sludge and synthetically precipitated sludge. After the P-dissolution, the recovery of phosphorus can take place through the precipitation of struvite, which is a valuable fertilizer and can be applied directly on agricultural fields.

Phosphorus Stripping of Bio-P Sludge and Enhanced Nutrient Recovery

Blanca M. Gonzalez Silva, Dag B Fiksdal, Chunbo He, Sveinung Sægrov, Stein W Østerhus

Phosphate from bio-P sludge can precipitate uncontrolled in the sludge treatment line and decrease the potential for phosphorus recovery. The presence of an anaerobic unit (or equivalent) before the pre-dewatering stage could favor early release of phosphorus and avoid uncontrolled struvite precipitation. Through a series of kinetic experiments of P stripping, a Michaelis-Menten curve was calculated. The use of Vmax and Km can then determine the potential release of phosphorus for any given Bio-P sludge. A Strong correlation between PO4-P and Mg2+ release and changes in conductivity was found. The results of this work can contribute to generate and optimize P-rich streams and enhance the phosphorus recovery.

Newly Developed Materials for Phosphorus Removal Recovery and Reuse in Decentralized Wastewater Treatment

Solvei Jensen, Frances Helen Blaikie, Helmer Soehoel, Juan A. Alvarez, Hans Brix, Carlos Arias

A screening of >20 materials submitted to engineered coating processes to increase the phosphorus (P) sorption capacity has been running for the past year. The resulting materials are being tested using adsorption isotherm experiments and revealed materials with promising P removal potential, which are currently being further investigated with column experiments, as well as, with external filters installed in real scale wastewater treatment plants. Since one of the objectives also was to recover and reuse nutrients, experiments are currently being performed to assess if the P bound to the material is bioavailable, for use as a nutrient source for plant uptake. The development of the materials constitutes a useful technology in decentralized wastewater treatment systems, which may promote a more circular nutrient cycle, hence, linking removal closer to recovery and reuse.

Optimization of a Pilot Bioacidification Reactor to Increase the Potential for Recovery of Phosphorus from Municipal Wastewater Sludge

Srdana Kolakovic, Jorge M.M. Santos, Maria A.M. Reis

This work aims to study the impact of different pH levels, organic loading rates and types of sludge on the performance of a pilot bioacidification reactor. This unit process is integrated with the StruviaTM technology to produce brushite or struvite in a new scheme implemented at full-scale conditions within the scope of the PhosForce project. The results achieved demonstrate the potential of using a bioacidification step to release more than 50% of phosphorous (P) from sludge and reduce 30% the content of volatile suspended solids (VSS) at 32ºC. The framework developed for the start-up of the reactor and acclimatisation of the acidogenic culture under different operational conditions will enable the replication of the PhosForce scheme to any municipal WWTP.

Adsorption-Desorption Mechanism and Kinetic Study of Synthesized Iron Doped Zeolite for Phosphate in Aqueous Phase

Md Saifuddin, Kwang Soo Kim

Fe-zeolite-A was synthesized using the sol-gel hydrothermal method. SEM, EDS, XRD, XPS, and FT-IR were performed to confirm Fe-zeolite-A synthesis and decipher adsorption and desorption mechanism. Fe-zeolite-A adsorbed/desorbed PO43- much faster than any other reported study. The XPS peak shift, FT-IR band shift and intensity change (–OH) confirmed ligand exchange mechanism. The EDS data, Si–O–Al band shift and intensity change in FT-IR and XPS peak and intensity change proved the involvement of Al in the sorption process. Na+ ion got exchanged with H+ ion in the phosphoric acid medium. The adsorption data fitted well with Langmuir's isotherm and pseudo-second-order kinetic model. The amount of $PO43^-$ adsorbed by the metal ions is 382.296 mg $PO43^-$ /g Fe and 56.296 mg $PO43^-$/g Al.

Struvite Production by Using Raw Seawater - How to Improve the Economy and Keep the Product Quality?

Sin Shaddel, Stein Østerhus

Seawater is an alternative magnesium source which potentially improves the overall economic and environmental footprint of struvite production compared to the use of pure magnesium salts. However, presence of other ions in seawater can reduce the phosphorus recovery potential and the simultaneous precipitation of other compounds may reduce the quality of produced struvite. The objective of this study was to keep the quality of final product and reduce the simultaneous precipitation of other compounds. The thermodynamic equilibrium modelling followed by lab-scale crystallization experiments by using seawater and MgCl2. The results showed that acceptable phosphorus recovery (80-90%) is achievable by using seawater. Further, the coprecipitation of calcium phosphates was successfully controlled and minimized by optimum selection of reaction pH and seawater volume (i.e. Mg:P and Mg:Ca molar ratios). The experimental results and economic evaluation showed that seawater could be a feasible alternative for pure magnesium sources in struvite production.

Role of Iron in Phosphorus Immobilization in a Novel vUCT-MBR System for Sewage Treatment

Shaoyu Deng, Jingbao Tian, Jiaqi Liu, Lingyue Wang, Xiang Cheng An

Fe-retrofitted UCT-MBR system was developed to induce in situ crystallization of vivianite (Fe3(PO4)2·8H2O) for recovering phosphorus (P) from sewage. The transformation of Fe in the system was particularly investigated to clarify its role in immobilizing P. Iron(III) bioreduction was effectively enhanced by establishing a relatively separated sludge phase in the anaerobic chamber. The generated Fe2+ and anaerobically released phosphate gave a value of saturation index (SI) for vivianite formation varying around 4, which is within the metastable zone favorable for the crystallization of this mineral. Analyses of the Fe phases indicate that vivianite was the only crystalline mineral detectable in the sludge. The vivianite crystals were able to endure oxygenated environments when being transported with sludge along the chambers with a tendency to accumulate in the MBR chamber as the vigorous aeration likely separated them from sludge flocs.

Critical Conditions of Struvite Growth and Recovery Using Hydrocyclone in Novel Struvite Crystallization Pilot Plant

Nari Park, Hyangyoun Chang, Yeoju Jang, Hyunman Lim, Jinhong Jung, Weonjae Kim

Struvite crystallization process can recover struvite crystal as valuable slow-release fertilizer from side stream of WWTPs. The purpose of this study was to investigate the critical conditions of struvite growth and recovery in a pilot plant. A novel struvite crystallization pilot plant (10 m3/d) was designed with a feeding system of MgO controlled by a pH controller and a hydrocyclone, and operated for 7 days (42 hours). The average removal efficiencies of PO4-P, NH4-N reached to 87.5%, 17.0% respectively. The precipitate from hydrocyclone was sifted by standard sieves and analysed by SEM-EDX and XRD. The weight fraction of 300 – 600 μm precipitate increased gradually from 7 to 74% in 3 days (18 hours). As a result of XRD, the crystalline structure of 150 – 600 μm precipitate was revealed as struvite and peaks of MgO, Mg(OH)2 and MgCO3 were not observed. It indicated that the critical conditions to recover struvite from side stream of WWTPs were 3 days (18 hours) of operation period and crystal size larger than 150 μm to be sifted.

Mathematical Model Application for Phosphorus Removal and Recovery Prediction in Continuous Flow Fixed-bed Columns

Daniel Dias, João Ribeiro, Jorge Santos, Samuela Guida, Giorgia Rubertlli, Ana Soares, Adrian Oehmen

This work focused on modelling a demonstration scale ion exchange (IEX) process for phosphorus (P) removal and consequent recovery from tertiary wastewater. P was removed by a column packed with a hybrid anion exchanger (HAIX) and regenerated with sodium hydroxide (NaOH). The coefficients of the Thomas model were calibrated and then validated for P removal, while recovery with the NaOH solution was also calibrated and validated. The Thomas model adjusted well to the experimental data. This approach for the model setup can be used as a tool for designing, optimising and ultimately predicting potential P removal and recovery in existing WWTP, therefore estimating the economic advantage of such a process compared with traditional processes as well as revenue of P recovery.

Cometabolic Production of Unusual Poly-β-Hydroxyalkanoates Using Enhanced Biological Phosphorus Removal Process in Sequencing Batch Reactors

Chencheng Le, Li Wang, Yan Zhou

Poly-β -hydroxyalkanoates (PHAs), a family of biodegradable polyesters that intracellularly synthesized by a wide range of bacteria as a reserve of carbon and energy, have gained global attention as sustainable alternatives to petroleum-based material. In this study, we employed different carbon substrates (acetate, propionate, butyrate and valerate) on the enhanced biological phosphorus removal (EBPR) biomass developed with either acetate or propionate as the sole carbon source to biosynthesize PHAs under the cometabolic condition. Using gas chromatography-mass spectrometer (GCMS), three unusual PHA monomers were discovered qualitatively and quantitatively in addition to other known monomers. This paper, for the first time, demonstrated the metabolic complexity and flexibility of non-axenic cultures in sequencing batch reactors to produce many novel high-value-added polyesters.

Session 3
VALUE ADDED PRODUCTS AND BIOPOLYMERS RECOVERY

Room Theatre

From Research to Full Scale Practice in Biopolymers Recovery

Rene Rozendal, PAQUES (NL)

René Rozendal is the Chief Technology Officer of Paques, where he leads an R&D group of ~25 people with a strong focus on resource recovery. Having worked in both academia and industry, he is well positioned to talk about the complexities involved when trying to bring scientific discoveries to full-scale implementation, particularly in the field of resource recovery. In his talk, he will focus on his experiences with scaling up the production of PHA from wastewater, but also on “lessons learned” from other resource recovery technologies (e.g., methane, sulphur, metals).

Self-extinguishing Property of Biopolymers Recovered from Waste Aerobic Granular Sludge

Yuemei Lin, Kim Nam

To convert waste sludge in municipal wastewater treatment plant into a resource and contribute to a circular economy, new biobased flame resistant material was developed by recovering biopolymers from aerobic granular sludge. The self-extinguishing property of the recovered biopolymer has been evaluated by following ISO and Federal Aviation standard tests. The biopolymer achieved self-extinguishment under severe heat radiation and after direct flame application due to its protein based structure.

WWTP Biorefinery for Polyhydroxyalkanoates (PHAs) Recovery from Cellulosic Primary Sludge

Vincenzo Conca, Cinzia Da Ros, Nicola Frison, Anna Laura Eusebi, Francesco Fatone

This work reports the results obtained by the long-term operation of the Short-Cut Enhance Phosphorus and PHA Recovery (SCEPPHAR) system at demonstration scale. The system consisted on the production of volatile fatty acids (VFAs) by mesophilic (37°C) acidogenic fermentation from cellulosic primary sludge by means of raw wastewater sieving at 350 µm. On the other hand, the process accomplished the partial ammonia oxidation of anaerobic reject water at relatively high nitrogen loading rate (vNLR 1.5 kgN/m3 d) and a PHA-driven denitritation by means of aerobic-feast and anoxic-famine regime. The overall nitrogen removal achieved was 85% while the selected biomass was able to accumulate up to 56% of PHA, which resulted to an overall production of 1-1.2 kgPHA/capita per year.

Producing Polyhydroxyalkanoates in HRAP Retrofitted for Wastewater Treatment with Phototrophic Purple Bacteria

Joana Fradinho, Juliana Almeida, Estaban Serrano, Adrian Oehmen, Enrique Lara, Maria Reis

Phototrophic mixed cultures (PMCs) were recently proposed as new microbial systems for polyhydroxyalkanoates (PHA) production. These cultures are enriched in phototrophic purple bacteria (PPB) that can obtain energy from light and therefore, do not require aeration to accumulate PHA, leading to more cost-effective PHA producing systems. The present work evaluated for the first time the possibility of retrofitting already existing High Rate Algae Ponds (HRAP) used for wastewater treatment, adapting their operation for PHA production with PPB, under local outdoor conditions. By operating the ponds under a carbon feast and famine strategy, the initial algae culture was successfully converted into a PMC enriched in PHA producing PPB. These first results at demonstration scale showed that the culture could attain up to 30% PHA/VSS content, indicating that PHA can be produced under natural illumination conditions in outdoor systems while treating real wastewater.

An Urban Biorefinery for Food Waste and Biological Sludge Conversion into Polyhydroxyalkanoates and Biogas

Giulia Moretto, Francesco Valentino, David Bolzonella, Paolo Pavan, Mauro Majone

This study deals with the implementation of an urban biorefinery technology chain in the Treviso municipality territorial context (70.000 PE). Added-value bioproducts (i.e. polyhydroxyalkanoates, PHA) and bioenergy production have been assessed from the mixture of the two most representative urban waste streams: the organic fraction of municipal solid waste (OFMSW) and the biological waste activated sludge (WAS).

Combined Wastewater Treatment and Bioflocculant Recovery

Victor Ajao, Harry Bruning, Huub Rijnaarts, Hardy Temmink

Here, we demonstrate the recovery and use of extracellular polymeric substances (EPS) from industrial wastewater as effective and eco-friendly flocculants. In this study, EPS were produced and extracted from two bioreactors, respectively treating fresh and saline wastewater. Increasing the carbon/nitrogen ratio (applying nitrogen limitation strategy) in the fresh and saline reactors enhanced EPS recovery (g EPS-COD/g CODinfluent) from 4 and 9 % (at COD/N 5) to 54 and 36 % (COD/N 100), respectively. These natural flocculants showed high flocculation performances (>75 % turbidity removal and a maximum of 92 %) using (saline) kaolin clay suspension as a model to mimic saline and non-saline (waste) water.

Rapid and Selective (Electro)catalytic Removal and Recovery of Sulfide from Wastewater

Natalia Sergienko, Jelena Radjenovic

Sulfide is recognized as a major problem in municipal and industrial wastewater treatment and collection systems due to its toxicity, malodour and biogenic corrosion. Here we propose a low-cost in situ method for sulfide removal using electrochemical cell equipped with MnOx-coated electrodes, which not only allows robust sulfide oxidation to sulfur, but also enables sulfur recovery in the form of concentrated sulfide solution and complete separation from the wastewater. Sulfide removal mainly occurs due to catalytic reaction between MnOx and sulfide ion. Anodic polarization of the material not only slightly enhances the process performance, but enables continuous regeneration of the MnOx after the oxidation of sulfide. Sulfur deposited at the electrode could be easily recovered by cathodic polarization of the loaded material, which helps to avoid material passivation without affecting stability of MnOx coating and yields a concentrated sulfide solution.

Sulfur Recovery in Biomethane Upgrading Plant

Davide Ravezzani, Ottavia Burzi, Luca Pedrazzi, Davide Scaglione

Sulfur is an essential element for life, in the form of organosulfur compounds or metal sulfides. It is one of the core chemical elements needed for biochemical functioning and an essential macronutrient for all living organisms. Sulfur deficiency has become widespread in many countries in Europe: its importance and future scarcity encouraged the development of an idea for its recovery in the biogas treatment line through a chemical H2S oxidation with biological regeneration of the solution. The main project driver is the resource recovery: transforming a waste into a product, a potential issue/problem into a new resource/opportunity. The possibility to recover sulfur can be exploited in almost every biogas treatment line once the presented technology for desulfurization is implemented.

Salt and Humic Substances Recovery as A Solution to Anion Exchange Brine Management

Elisabeth Vaudevire, Isaac Daniel

This paper highlights the main discoveries from six years of R&D effort toward developing a treatment solution for a waste brine from a drinking water plant using anion exchange for NOM removal. Due to the nature of NOM in the brine i.e. humic (HA) and fulvic acid (FA), which find a number of applications in the agriculture industry, their recovery as a secondary product was assessed on pilot scale; in addition to the recovery of monovalent salts for onsite recycling. The research considers the technologies for secondary product extraction, the potential application of HA and FA as well as the regulatory quality requirements.

Biotechnological Removal of H2S Under Haloalkaline Conditions

Karine Kiragosyan, Magali Picard, Jelmer Dijkstra, Pieter van Veelen,Johannes Klok, Pawel Roman, Albert J.H. Janssen

Removal of sulfur containing compounds from sour gas streams plays a crucial role in environmental protection by decreasing sulfur dioxide emissions into the atmosphere. Among all available desulfurization technologies, biological processes are the most sustainable technologies for hydrogen sulfide removal. Besides H2S, sour gas streams can contain volatile organic sulfur compounds, such as thiols. Both organic and inorganic sulfur compounds are toxic, characterized with the obnoxious smell and potential corrosive effects. A recent pilot study showed that with the addition of anaerobic bioreactor sulfur selectivity increased and the process did not abrupt with thiols addition. The added anaerobic bioreactor enabled selective pressure for sulfide oxidizing bacteria which are able to oxidize sulfide more efficiently. However, further insight into the underlining processes is required to fully understand work of newly proposed line-up.

FAMEs Estolides and Methyl-10-Hydroxystearate: Sewage Sludge as Possible Source of Biodiesel and Bio-lubricants of New Generation

Carlo Pastore, Luigi di Bitonto

In this work, a detailed characterization of the lipid component of sewage scum and primary sludge was reported. Samples up-taken from several wastewater treatment plants (WWTPs) were processed, and lipids were efficiently extracted, recovered and analysed. The most important component were found to be free fatty acids (FFAs, 75-80%wt), whereas glycerides (mono-, di- and triglycerides) resulted almost absents. Besides FFAs, estolides and 10-hydroxystearic acid were also identified and quantified. Extracted lipids were

reacted with methanol through a direct esterification process, allowing the complete conversion of starting FFAs into fatty acid methyl esters (FAMEs, yield > 99%) under very mild conditions (345 K, 6h) to be obtained. At the end, pure FAMEs can be efficiently separated from estolides and methyl-10-hydroxystearate through a vacuum distillation, definitively completing the valorisation of the overall separated lipid phase.

CyreneTM as a new bioderived green solvent for membrane preparation

Alberto Figoli, Tiziana Marino, Antonio Molino, Francesca Russo, Francesco Galiano

In this work, Cyrene™ was used for the first time for the preparation of for polyethersulfone (PES) and poly (vinylidene fluoride) (PVDF) membranes via phase inversion technique. The morphology of the membrane could be tailored by varying the exposure time of the nascent film (from 0 to 5 min) to humidity prior immersion in the coagulation bath. Membranes were fully characterised in terms of morphology, thickness, porosity, contact angle, pore size and water permeability. Ultrafiltration and microfiltration membranes were obtained showing the potentiality of this new green solvent for producing membranes for water treatment applications.

Session 4
NUTRIENTS RECOVERY AND REUSE

Room Auditorium

Nutrient Upcycling from Wastewater Treatment: Technical and Non-Technical Roadmap

Maria Albuquergue, Celine Bouchereau, Erik Bundgaard, Marisa Cunha, Ana Bisinella, Bruno Tisserand

The water utilities sector has witnessed the eve of a paradigm shift from dissipative treatment to resource recovery. Even more broadly, an ecosystemic link exists between water cycle management and agriculture, the later providing a number of ecosystem services (or dyservices) with impact to water cycle and food security. Acutely aware of this link and engaged toward resource recovery, Veolia has developed a comprehensive research and development program that combines disciplines such as process design, systems analysis, simulation, multi-objective optimization, agronomic sciences, economics and social studies aiming at supporting value chain transition strategies and developing decision support tools.

High-solid Thermophilic Anaerobic Digestion with Ammonia and Phosphate Recovery

Masanobu Takashima, Junichi Yaguchi

This study investigated high-solid thermophilic anaerobic digestion fed with sewage sludge of 9–10% total solids. Ammonia stripping in a side-stream configuration and selective adsorption by porous iron hydroxide were introduced to digested sludge, respectively, for ammonia and phosphate recovery. The laboratory anaerobic digester performed well at the hydraulic retention time of 20 days and loading rate of 3.96 gVS/L-d, showing VS destruction of 57.8% and gas production of 0.522 NL/gVS. The stripping device was operated batchwise at 70oC and initial pH of appro. 9.0 for 2 hours, recovering 20.7% of influent nitrogen as ammonia and keeping total ammonia at 1,760 mgN/L in digester. Also, 54.6% of influent phosphorus was recovered as phosphate by the selective adsorption, when conducted at the pH of 4–5 for 24 hours. The lower pH was advantageous for saving the amount of cationic polymer added and improving the dewatering characteristics of digested sludge.

Pilot Scale Studies on Nutrient and Biochar Recovery from Wastewater and Sewage Sludge

Laura Rossi, Aino Kainulainen

Wastewaters are a valuable sink of nutrients and other substances. A lot of research has been done to recover these resources more efficiently. Helsinki Region Environmental Services HSY is developing a nutrient recovery process called RAVITA where phosphorus is recovered directly from water phase as its own stream. This gives more flexibility to biological sludge treatment for example through pyrolysis. Furthermore, RAVITA can be combined to nitrogen recovery from reject waters. Products from these processes are phosphoric acid and ammonium phosphate and sludge-derived biochar.

Fractionating Various Nutrient Ions for Phosphate Recovery from Swine Wastewater Using Selective Electrodialysis

Zhi-Long Ye, Boudewijn Meeschaert, Shaoho Chen, Karel Ghyselbrecht, Xin Ye, Annick Monballiu, Luc Pinoy

This study aimed to fractionate various nutrient anions and cations in swine wastewater synchronously, including PO43-, SO42-, Mg2+ and Ca2+, into two streams. The recovered streams were further paired together for phosphorus recovery. A novel electrodialysis process was developed by integrating monovalent selective anion and cation exchange membranes into an electrodialysis stack. Results revealed that the separation of nutrient ions was achieved effectively by fractionating PO43- and SO42- into the anionic product stream, whereas bivalent cations (Mg2+ and Ca2+) were extracted in the cationic product stream. Further experiments were conducted for phosphorus recovery by pairing the recovered product streams, which revealed that phosphate precipitation could be achieved by using inherent Ca2+ and Mg2+ in the wastewater without dosing external cation sources.

Optimised Nutrient Recovery from Biogas Digestate by Solid/liquid Separation and Membrane Treatment

Sandra Rosenberger

Anaerobic digestion products of agricultural biogas plants are characterised by high nitrogen, phosphorus, and potassium content. In three scale-up steps, a membrane based digestate treatment process of solid-liquid-separation, ultrafiltration, and reverse osmosis for nutrient recovery was investigated. Lab-scale trials delivered a very good understanding of fluid properties and subsequent ultrafiltration performance, which is the limiting process step in terms of energy demand and operation costs. In semi-technical experiments, optimisation, and design parameters were developed, which were subsequently applied to pilot-scale tests at two full-scale biogas plants. The process optimisation resulted in 50 % energy reduction of the ultrafiltration step. About 36 % of the sludge volume was recovered as dischargeable water, 20 % as solid N/P-fertiliser, and 44 % as liquid N/K-fertiliser.

Nutrient Recovery from the Perspective of the Flemish Wastewater Utility

Bart Saerens, Francis Meerburg, Marjoleine Weemaes

Aquafin, the Flemish wastewater utility, is keen to contribute to the circular economy and put nutrient recovery to practice. This presentation highlights the situations in Flanders: nutrient flows and recovery potential through municipal wastewater, existing initiatives, cost and life cycle assessment, promising technologies, and possible outlook to further implementation.

Reusable Magnetic Sorbent Materials for Advanced Wastewater Treatment and Nutrient Recovery

Asya Drenkova-Tuhtan, Carsten Meyer, Caleb Inskeep, Karl Mandel, Thomas Ballweg, Michael Schneider, Carsten Gellermann, Heidrun Steinmetz

The use of magnetite (Fe3O4) seeded sorbent materials for water purification purposes, pollution control and resources recovery is gaining a growing popularity due to the convenience of their ability to be harvested magnetically, regenerated and reused numerous times. Herewith we propose a technology using magnetic carrier particles (5-25 µm) modified with a tailored adsorbent material for the selective and reversible sorption of phosphorus from pre treated wastewater (reaching ultra low effluent concentration < 0.05 mg/L total phosphorus) or from other P rich media (sludge liquor, industrial wastewaters, etc). The engineered micro sorbents can be extracted magnetically from water, regenerated in an alkaline solution, where P desorption and enrichment take place, and reused again. The P rich solution is a source for further recovery of the valuable nutrient, e.g. via precipitation of struvite. Moreover, we are currently developing regenerable magnetic activated carbon as a reusable resource for the elimination and simultaneous degradation of organic micropollutants from wastewater.

Hydrothermal Carbonization (HTC) for the Nutrient and Energy Recovery from Digested Sewage Sludge

Anna Hämäläinen, Jukka Rintalla, Marika Kokko, Viljami Kinnunen, Tuomo Hilli

Digested sewage sludge (DSS) contains valuable nutrients and organic carbon but has limited potential in agriculture due to possible hazardous contaminants originating from wastewater. In this study, the ability of hydrothermal carbonization (HTC) to preserve the nutrients and increase the energy value of DSS was evaluated. The nutrients and solids were characterised from the liquid filtrates and solid hydrchars. It was also studied if the liquid fraction could be fed back to anaerobic digestion. Hydrochar could be combusted for energy recovery, or used as a soil-additive, depending on its fuel properties and nutrient content.

High Efficiency Phosphorus Recovery and Sewage Sludge Valorization via Hydrothermal Carbonization

Gianni Andreottola, Maurizio Volpe, Luisa Mariafioti, Luca Fiori

Hydrothermal carbonization (HTC) of sewage sludge was carried out at 190 and 210 °C and 1 or 3 hours of reaction time to investigate phosphorous segregation into the resulting solid residue (hydrochar) and its subsequent recovery via acid leaching and precipitation. HTC treatment has shown to effectively segregate up to 90 wt% phosphorus for HTC carried out at 190 °C 1 h. Acid leaching, using HCl 4 M at room temperature, followed by sodium hydroxide addition (solution at 5 M) up to pH 9.0, led to the formation of phosphate precipitate ensuring a global phosphorous recovery, when considering the starting material, up to 72 wt% dry basis. ICP-OES analysis showed that the concentration of heavy metals like Al, Cd, Fe, Pb, Mn, Zn etc. into the acid leached hydrochar residues were sensibly reduced, making such residues promising materials to be used as fertilizers.

Simultaneous Nitrogen Removal and Phosphorous Recovery in Anoxic and Microaerobic Biofilm Systems

Nilesh Badgujar, Francesco Di Capua, Stefano Papirio, Francesco Pirozzi, Piet Lens, Giovanni Esposito

Simultaneous nitrogen and phosphorous removal was investigated in different biofilm systems, i.e. two packed-bed reactors (PBRs) performing autotrophic denitrification via anoxic pyrite oxidation and two moving bed biological reactors (MBBRs) performing simultaneous nitrification denitrification (SND) under different dissolved oxygen (DO) regimes. Nitrogen and phosphorous removal ≥ 80% was observed in pyrite-packed PBRs via chemical precipitation with Fe3+ at HRT ≥ 5. SND in a microaerobic MBBR resulted in biological nitrogen and phosphorous removal above 60% and 70%, respectively. Lower nutrient removal efficiencies were obtained in another MBBR alternating anoxic and aerobic conditions.

Session 5
PHOSPHORUS RECOVERY: PILOT, DEMO AND FULL-SCALE TECHNOLOGIES

Room Theatre

Self-sustaining Sludge Smouldering: Towards On-Site Complete Sludge Destruction and P Recovery

Jose Torero, University College (UK)

Incineration has been used for decades as a means to destroy waste water sludge. The ash from incineration can many times deliver compounds that can be used in multiple applications. While the interest in achieving effective recovery has increased and incineration processes have been modified to more effectively deliver valuable compounds, the main loss remains the energy required to evaporate water. Effective recovery of energy from organic waste requires maintaining combustion temperatures above quenching conditions and therefore the presence of large quantities of water requires major addition of supplemental energy. The alternative of pre-incineration water removal is also energy intensive. Thus extinction limits efficiency enhancement resulting in major and unavoidable energy consumption. This presentation will discuss the use of smouldering combustion as the most efficient means of recovering energy from combustion and as an efficient mechanism to incinerate waste water sludge with high water content (>70%). The objective is full resource recovery in the absence of any external energy supply.

Ash2Phos -- Clean Commercial Products from Sludge Ash

Yariv Cohen, John Svärd

EasyMining Sweden has developed a process for phosphorus recovery from sludge ash named Ash2Phos. The process is based on wet chemical processing of mono-incinerated sludge ash. Phosphorus is first recovered in form of clean intermediate calcium phosphate. Several options exist for converting the intermediate calcium phosphate into final commercial products. After successful pilot trails, work is ongoing on the engineering of the first full-scale plant in Sweden.

4 Years of Phosphorus Recovery at WWTP Amsterdam West

Alex Veltman, Jacquelien de Schutter

At the WWTP Amsterdam West (in total 1,6 million people equivalent) with enhanced biological phosphorus removal massive scaling problems occurred after digestion of the primary and secondary sludge. The scaling was identified as struvite. Struvite is magnesium ammonium phosphate, a crystal with commercial value as a fertilizer. During the anaerobic digestion process biologically bound phosphorus is released into the liquid phase and with the present ammonium and magnesium levels struvite formation is very likely.

Thermochemical P-Recovery from Sewage Sludge Ash

Schaaf Tanja, Ulbrich Julian, Orth Andreas

Phosphorus (P)-components can be recovered from sewage sludge ashes (SSA) and be used as fertilizer by improving the bioavailability of P in the ash by means of the AshDec® process. In this process SSA is treated thermochemically at 900 °C with a sodium compound and dried sewage sludge. Critical heavy metal content of e.g. cadmium, lead and arsenic can be reduced significantly. After treatment the present P - compound is not water soluble reduces the risk of runoff, leaching and fixation. Several pot and field experiments showed a similar performance of the AshDec® - product as Triple Superphosphate (TSP). Experiments in laboratory and industrial scale demonstrated that even with variation of process parameters a steady high-quality product was generated.

The Inhibitory Effects of Free Nitrous Acid and Free Ammonia on the Aerobic Phosphorous Utilization Rate

Dimitris Andreadakis, Constantinos Noutsopoulos, Gerasimos Ragkiskatos, Kyriaki Argyropoulou, Theodora V. Missirli, Daniel Mamais, Simos Malamis

Laboratory scale experiments were conducted to study the inhibitory effects of free ammonia (FA) and free nitrous acid (FNA) on the enhanced biological removal (EBPR) process. The aerobic phosphorous utilization rate (PUR) was found to be inhibited by 50% under a FNA concentration of approximately 0.0015 mg/L and was fully inhibited at the FNA concentration of 0.013 mg/L. FA was also found to inhibit phosphorous removal with an observed 50% inhibition of the aerobic PUR under the FA concentration of approximately 8 mg/L.

Phosphorus and Ammonia Removal and Recovery through Ion Exchange (IEX) Process at Demonstration Scale

Samuela Guida, Georgia Rubertelli, Bruce Jefferson, Ana Soares

The operational performance of a demonstration scale ion exchange process, treating 10 m3 /day of secondary treated wastewater, was investigated. For the removal of ammonia and phosphorus, a synthetic zeolite and hybrid anion exchanger (HAIX) were used, respectively. To ensure the economic feasibility of the process, the resins regenerant solutions were re-used and recycled back to the process after the nutrients were recovered. After 1.8 years of operation, the synthetic zeolite removed up to 98% of the initial NH4-N and regenerant reached 689 mg NH4-N/L, after being reused 5 consecutive cycles. The recovery of the NH4+ as ammonium sulphate through stripping process was investigated (recovery >90%). The HAIX underwent 56 cycles of adsorption and regeneration without any significant loss in capacity. The sodium hydroxide used as regenerant reached 490-572 mg PO4-P/L after 9 consecutive cycles and the phosphorus was recovered by precipitation as hydroxyapatite.

Chemical vs. Biological Phosphorus Removal: Full-scale Process Optimisation for Resources Saving

Laura Menoni, Gergio Bertanza, Roberta Pedrazanni

In this work, the optimisation of phosphorus removal process was carried out at full-scale: both chemical and biological techniques were considered in order to obtain resources saving. Full-scale experimental tests were performed to find the best coagulant and polyelectrolyte (and their dosages) for chemical removal. Moreover, some different alternatives were compared to define the optimal configuration concerning the percentage of the total flowrate to be submitted to tertiary treatments. Finally, the efficiency and costs associated to this optimized chemical phosphorus abatement were compared to the biological removal option. This can be considered as a fundamental starting point for the implementation of resource recovery technologies.

Mainstream SCEPPHAR Configuration for Integrating P and PHA Recovery in the Water Line of WWTPs

Oriol Larriba, Zivko Juznic-Zonta, Borja Solis, Juan Baeza, Albert Guisasola

This work presents a novel pilot-scale configuration, mainstream SCHEPPAR (Short-Cut Enhanced Phosphorus and PolyHydroxyAlkanoate Recovery), within the framework of resource recovery. This configuration is designed to: i) efficiently remove C, N and P, ii) recover up to 50% of incoming phosphorus in struvite form, iii) reduce aeration requirements up to 25%, and iv) recover about 9% of influent organic matter as PHA.

Boosting the P Extraction from the Sludge by Rearranging the Sludge Line in a WWTP

Ramón Barat, Miguel Roldán, José Ferrer, Nuria Martí, Teresa Alvariño, Francisco Javier Navarro

Currently, it is essential the application of new P management strategies to enhance its recovery in the Waste Water Treatment Plants (WWTP). This paper shows a comparative assessment by simulation of two different sludge line configurations aiming to maximize the P extraction and so its final recovery. For this purpose, it was selected the Murcia-Este WWTP as the site where both alternatives were evaluated. Alternative 1 was based in the P separation through the sludge elutriation over the primary thickeners and Alternative 2 was based in the WASSTRIPÒ process. Both alternatives were able to achieve similar results for the P extraction (between 43.1% and 48.3% of P extracted over the influent P). However, the CAPEX and OPEX were significantly higher for the Alternative 2, making more attractive the sludge line configuration based on the elutriation scheme.

Phosphorus Recovery and Management in Alto Trevigiano Servizi: from Pioneer Struvite Recovery to current Regional Strategies

Alberto Piasentin, Luca Girotto, Matteo Tartini, Roberto Durigon, Pierpaolo Florian

Alto Trevigiano Servizi is a public-owned water utility that manages urban water cycle services of 52 municipalities in Veneto region, North-East of Italy. Innovative technological solutions and strategies during the years have permitted to developed and realize an integrated approach in the management and recovery of phosphorus. Treviso wastewater treatment plant developed one of the first demonstrative area to recovery struvite from urban wastewater. Moreover, the Short Cut Enhanced Phosphorus and PHA Recovery, integrated in Carbonera, is actually permitting the integration of conventional biogas recovery from cellulosic primary sludge with the energy-efficient nitrogen removal via-nitrite from sludge reject water and the recovery of PHA and struvite. Finally, a future upgrade of Castelfranco Salvatroda plant, focused on centralized and smart management of wastewater sludge, will permit to innovate and valorise circular economy in the territorial scenario.

Session 6
ECONOMIC AND ENVIRONMENTAL SUSTAINABILITY ASSESSMENT

Room 6

Life Cycle Assessment of Material Recovery from Municipal Wastewater: Circular Economy with Environmental Benefits?

Christian Remy, Jennifer Misiukas, Carlijn Lahaye, Zivco Jucnic-Zonta, Juan Baeza, Nicola Frison, Bruno Ferreira, Gorostegi Guerra, Sergio Salas, Joan Jorda, Luis Enriques

Recovery of valuable materials from municipal wastewater is one approach to realize circular economy in the wastewater sector. Different technologies have been tested and applied to recover products such as cellulose, bioplastics, or struvite within a wastewater treatment plant (WWTP). However, material recovery also introduces new process steps into the treatment scheme, which require additional energy or chemicals and related greenhouse gas emissions. From an environmental perspective, Life Cycle Assessment (LCA) is a suitable tool to analyse the entire system of material recovery from WWTPs, including the potential value chains for product valorisation. The present paper investigates different technologies for material recovery with LCA based on data of industrial-scale demonstration trials and shows that material recovery can be realized with distinct environmental benefits, also due to positive side effects on the overall treatment scheme of the WWTP.

Environmental and Economic Assessment of Solar-assisted Thermal Energy Recovery from Wastewater

Ivan Muñoz, Francisco Portillo, Sabina Rosiek, Javier Francisco, Iñaki Acasuso, Valentina Piergrossi, Marco Disanctis, Silvia Chimienti, Claudio Di Iaconi

The integration of an off-grid solar-assisted heat pump (SHP) and a sequencing batch biofilter granular reactor (SBBGR) for thermal energy recovery from wastewater was assessed by means of life cycle assessment (LCA) and life cycle costing (LCC). This integrated system was compared to a reference situation where wastewater is treated in a conventional WWTP. The results show clear environmental and economic benefits, such as a 42% reduction in greenhouse-gas emissions and a cost reduction of 53%.

Life Cycle Assessment of Nutrient Recovery from Wastewater - Current Practices and Insights

Ka Leung Lam, Ljiljana Zlatanović, Jan Peter van der Hoek

Life cycle assessment (LCA) is an established methodology to assess the potential environmental impacts of products and processes. We reviewed 49 recent LCA studies (2010-2019) related to nutrient recovery from wastewater to synthesise some current practices and insights. Their scopes, general results, variations, limitations and uncertainty management are discussed. Most studies are either comparing the environmental impacts of having recovery versus without recovery or comparing the environmental impacts of different recovery alternatives. Most studies reported an overall positive environmental performance for nutrient recovery from wastewater, especially when combining with source separation of human excreta. There are many opportunities to improve the LCA practice such as improving methodological consistency, ensuring transparency of inventory and methods, considering result uncertainty, and connecting the recovered nutrient products to local factors.

The Economics Behind the Combination of AnMBR and FO Technologies for Municipal Wastewater Treatment

Sergi Vinardell, Sergi Astals, Joan Mata-Álvarez, Joan Dosta

Anaerobic membrane bioreactor (AnMBR) technology is drawing attention for municipal wastewater treatment and resource recovery. However, the low concentration of organics in sewage compromises the economic and technical feasibility of this application. Forward osmosis (FO) stands as an excellent platform to pre-concentrate sewage and overcome these limitations. This techno-economic study evaluates 7 different scenarios for municipal wastewater treatment, including 6 scenarios where AnMBR and FO are combined. The results of this study show that the costs of integrating FO with AnMBR are driven by FO recovery. Although an integrated facility where FO is used for pre-concentration and AnMBR for sewage treatment may be a feasible approach, FO flux improvements are still required to boost the competitiveness of the technology.

Circular Economy in Water Sector and Italian Regulation Activities

Andrea Guerrini

In the circular economy system, the water sector is increasingly becoming a field of concrete experimentation and application on an industrial scale of techniques aimed at saving and producing energy, and at the production of materials from water treatment cycles. The water cycle itself represents a “circular economy system” connected to the use of water resources and to the processes of recovery of “secondary” resources, such as energy and materials. This presentation aims to identify the measures that can be taken by the institutions responsible for regulating the sector in order to encourage operators to invest in the circular economy and to develop corporate policies based on environmental sustainability and efficiency. It describes: the main actions for the recovery of energy and matter from the management of the water cycle; the current configuration of the regulatory measures adopted in Italy by ARERA; some future developments in regulation policies.

Novel Financing Strategies to Simultaneously Advance Sanitation and Agriculture Through Nutrient Recovery

Hannah Lohman, John Trimmer, David Katende, Muwonge Mubasira, Maria Nagirinya, Fred Nsereko, Noble Banadda, Jeremy Guest

Although access to safely managed sanitation is improving, over two billion people still do not have basic sanitation globally. The sixth Sustainable Development Goal seeks to achieve universal sanitation access; however, limitations in financial resources demand innovative approaches to meet this goal. Resource

recovery may serve as a mechanism to improve access to agricultural nutrients, thereby creating income streams that could help offset sanitation costs. The objective of this work was to determine if resource recovery sanitation can enable profitable bodily waste management through the sale of recovered nutrients. A techno-economic analysis was used to assess the profitability of business models for use in Uganda. Results show that profitability can be achieved at a nutrient selling price at or below fertilizer market value in Uganda. This research makes a case to support innovative sanitation strategies and recovered nutrient markets in areas with poor fertilizer and sanitation access.

Integration of Statistical Monitoring and Life Cycle Assessment to Evaluate the Sustainability Behavior of WWTPs

Peyo Stanchev, Vasileia Vasilaki, Francesco Fatone, Evina Katsou

This paper presents an innovative approach of coupling statistical methods and life cycle analysis to evaluate the static and dynamic sustainability performance of wastewater treatment plants (WWTP) with activated sludge process. Statistical analysis has been performed including: screening stage to improve data quality, detection and diagnose of abnormal events and faults, identification of operational states and data clustering. For the identified periods and operational states, static and dynamic Life Cycle Assessment (LCA) analysis has been performed following the ReCiPe Midpoint (H) method to evaluate the environmental impact of the WWTPs. Moreover, the trade-offs between direct and indirect emissions in each impact category and between the selected impact categories have been analysed in relation to the different WWTP operational states and environmental conditions. On this basis, comprehensive correlation and regression analysis have been conducted to reveal the statistical correlation between the WWTP inflow, operational, effluent parameters and the environmental performance. The approach has been tested using two-year operational data and dedicated direct GHG monitoring campaigns from a full-scale WWTP, located in UK. This study provides a methodological framework to analyse the sustainability performance of wastewater treatment processes and a step towards model predictive control of WWTPs including environmental aspects.

Evaluation and Cost-efficiency of On-site Wastewater Reuse Systems

Darja Istenič, Nataša Atanasova, Aleksandra Krivograd Klemenčič, Franja Prosenc, Tjasa Griessler Bulc

Green technologies can offer various benefits due to their nature-based solution approach focusing on producing valuable products while treating wastewater (WW). The composition of WW corresponds to the willows' and algae's nutrient needs which enables efficient water treatment and biomass production. The results on pilot evapotranspirative willow system (EWS) and algae-based technology (ABT) showed that for the treatment of WW produced by 1 person, 42 would be needed for EWS and 5-10 m2 for ABT, while producing 140-170 kg of wood biomass and 73-146 kg of algae biomass per PE/year. The study lays the foundation for future research on the WW treatment with EWS and ABT with the aim to close nutrient cycles and produce environmentally-friendly fertilizers in the form of treated effluent and wooden or algae biomass.

Life Cycle Assessment and Cost-Benefit Analysis of a Multi-Step Process of Olive Mill Wastewater Valorization through Polyphenol Adsorption and Anaerobic Digestion

Dario Frascari, Tjerk Wandenaar, Emmanuel Oertlè, Atef Jaouani, Davide Pinelli

Olive mill wastewaters (OMWs) represent a major environmental concern due to their high organic load and phytotoxic activity. The selective recovery of phenolic compounds (PCs) from OMW is promising, thanks to the antioxidant and antimicrobial properties of PCs. The goal of this work was to perform the life cycle assessment (LCA) and cost-benefit analysis (CBA) of a full-scale process of PC adsorption/desorption on resin Amberlite XAD16N designed on the basis of laboratory tests aimed at performing a preliminary process optimization. The results indicate that the proposed technology, if integrated with an anaerobic digestion step, represents a promising solution for the treatment and valorisation of OMW, a major agro-industrial waste in Mediterranean countries.

Measuring the Circularity Potential of an Eco-friendly Touristic Facility in a Mediterranean Island

Chrysanthi-Elisabeth Nika, Peyo Stanchev, Evina Katsou

The adoption of Circular Economy (CE) in water sector, as an alternative to the traditional linear model of water systems has gained popularity to tackle the problem of reduced water availability and jeopardized water quality by promoting water reuse and recycling. However, the lack of a circularity assessment methodology of water systems considering renewable raw materials and biological processes is limiting

the wider implementation of the concept. The current work aims at the development and application of a circular assessment methodology of such systems, taking into consideration metabolic profiles of water, and water-related energy and nutrients, environmental impacts, socio-economic values and products valorization pathways. Performance indicators that can be used as metrics of circularity (including technical cycles, environmental and economic aspects) were derived. The methodology was applied in an eco-friendly touristic facility (Ecolodge) in Tinos Island, Greece enabling the quantification of the proposed indicators with validated data.

Session 7
URINE VALORIZATION AND WATER REUSE
Room Theatre

The Beneficiation of Urine and Faecal Fractions from Urine-Diversion Double-Vault Toilets (UDDTs) in Ethekwini Municipality South Africa

Sudhir Pillay, Water Research Commission (ZA)

The Ethekwini Municipality has around 80,000 Urine Diversion Double-Vault Toilets (UDDTs). To explore the beneficiation of source-separated waste from these toilets, the municipality has commissioned a Black Soldier Fly (BSF) larvae processing plant and a struvite processing facility for the faecal and urine fractions, respectively. A key research need identified for the continued beneficiation of waste was the microbial risks associated with struvite production from urine and optimisation of the BSF larvae growth and subsequent pathogen and sludge volume reduction capabilities. The research provided key insights to the source of contamination from struvite-derived urine and optimal conditions for digestion of UDDT faecal sludge.

Achieving Nutrient Resource Efficiency through Urine Separation Processing and Reuse: A Comprehensive Study

Nancy Love, Glen Daigger

Urine separation, processing and reuse introduces a way to accomplish both nitrogen and phosphorus recovery. Challenges over the scalability of this practice requires both field and model-based analyses. This presentation will convey the results of a multifaceted study that includes experimental work (collecting urine, processing it, applying it as a fertilizer, and evaluating the food crops produced), emerging contaminant assessment, life cycle assessment modeling, user behavior assessment, and demonstration of a building-scale “smart” urine separation and processing system.

Safe Production of Microbial Protein from Urine

Mark Dodds, Yifeng Zhang, Elena Toressi, Monika Skadborg, Barth F. Smets, Borja Perez Valverde

An electrochemical cell was used for ammonia extraction from urine. Extracted ammonia was free of trace elements and thus suitable for production of microbial protein. Protein quality was similar to that obtained using dAMS media for cultivation of methanotrophic bacteria.

Green Walls Optimized for Treatment and Reuse of Greywater

Fabio Masi, Alice Caruso, Elisa Magna, Silvia Fiore, Francesca Demichelis, Ana Galvao, Janoa Pisoeiro, Anacleto Rizzo, Luca Ridolfi, Fulvio Boano

Greywater can be a valuable non-conventional water resources for uses requiring a not-potable water quality, such as WC flushing and irrigation. Greenwalls can be an interesting nature-based solution to treat and reuse on site greywater. This study wants to present results from a pilot study, which investigated different mixtures of conventional and innovative materials used as growing media. The aim is to identify the most efficient green wall configurations in terms of treatment efficiency.

Improvement of Water Quality Through BAC Filtration in a Water Reclamation Plant

Laura Palli, Stefano Fiaschi, Michelle Allocca, Vittoria Viviani, Claudio Lubello, Riccardo Gori, Roberto Camissa, Donetella Fibbi

In the present work, a study on the effect of different dosage of oxygen in full scale biological activated carbon (BAC) filters has been carried out. In particular, the performance of the plant in removal of color, COD and ammonium have been evaluated. Comparing the average removal rates of these three parameters, the increase in oxygen dosage leads to an increase of 40% of ammonium removal, 10% of COD removal and 6% of color removal with respect to the low-oxygen filter. On the other hand, considering the costs for energy requirements and oxygen supply, costs for the two different dosages have been estimated to 0.033 €/m3 for filter with high oxygen and 0.009 €/m3 for filter with low oxygen. The amount of biomass in different sections of the two filters have also been carried out through respirometric tests. Results indicated that higher dosage of oxygen resulted in higher amount of biomass (about three times on average), well distributed through the depth of the filter.

Removal of Micropollutants from Wastewater by Rapeseed Simultaneous Biosorption

Irina Morasanu, Daniela Fighir Carmen Teodusio, Carmen Paduraru

This study is based on the evaluation of the rapeseed waste potential for the simultaneous biosorption of toxic metals and reactive dye from aqueous systems. Batch experiments were performed at room temperature (20±4°C), by varying the initial concentration of one of the micropollutants (15 – 150 mg/L), while the initial concentration of the other pollutant was at a fixed value (50 mg/L). Kinetic measurements were done at various molar ratios of lead and Reactive blue 19. Selectivity study implied a higher preference of the biosorbent for metal rather than dye. The experimental data for metal biosorption was well explained by both Langmuir and Freundlich isotherms. The maximum biosorption capacities were of 25.13 mg/g and 11.36 mg/g for Pb(II) ions and dye, respectively. The pseudo-second order model was able to satisfactorily predict the kinetics of biosorption in both cases. XPS analysis revealed the presence of metal on the biosorbent's surface.

Evaluation of Design Wastewater Treatment Plant Tertiary Process for Water Reuse with the Application of Modelling Tool

Paolo Cirello, Giancarlo Chechinni, Mario de Mola, Emilia Bernardini, Barbara Biagi

Application of a Waste Water Treatment Plant modelling tool, to verify the predictability and to improve the plant process and the tertiary treatment design in activated sludge treatment plant. The tool selected for the simulation is the software WEST by DHI. The case study presents the results of plant performance evaluation, with particularly attention on nutrients removal, and evaluation of tertiary treatment design.

An Integrated Waste-wastewater Management Approach to Increase Wastewater Reuse in Mediterranean Regions

Giuseppe Mancini, Antonella Luciano, Paolo Viotti, Debora Fino

The choice of appropriate and sustainable wastewater treatment and reuse schemes should be based on a careful and holistic analysis of several elements, considering their potential role of guaranteeing the global financial soundness of the project, as well as the necessary environmental and sanitary requirements. The aim of this paper is promote a shift of paradigm in the current management of both the organic fraction of urban waste, sludge management and wastewater reuse. Moreover the work aims to show as the role of the treated-wastewater storage phase, under proper operating conditions, can significantly increase the safety of reuse and its economic sustainabilty.

Recovery of Ammonia from Urine with an Open-loop Hollow Fiber Membrane Contactor

Junhui Zhang, Mengfei Xie, Haoxiang Yu, Dan Qu

In this study, an open-loop hollow fiber membrane contactor (HFMC) was developed to recover ammonium nitrogen (NH4+-N) from source-separated urine. The ammonia capture performance at various feed flow rates (v) were investigated, experimental results showed that the capture efficiency decreased from 80.26% to 33.07% and effluent total ammonium nitrogen (TAN) concentration increased from 9.80±7.51 mmol/L to 219.44±13.42 mmol/L when v increased from 1.62×10-5 to 32.49×10-5 m/s. Furthermore, a theoretical model has been developed based on resistance in series model, the overall mass transfer coefficients calculated by the model (Kov) and experimental data (Kov,experimental) had a great agreement. The mass transfer coefficient in the membrane pores (km) and lumen side (kl) kept constant and much larger than the shell side (ks). So, the ammonia mass transfer in the feed solution was the rate determining step during the ammonia capture process.

Application of Membrane Distillation for Optimal Fertilizer Recovery from Human Urine

Mekdimu Damtie, Federico Volpin, Minwei Yao, Leonard Tijing, Yun-Chul Woo, June-Seok Choi, Ho-Kyong Shon

Membrane distillation (MD) process can be applied in wastewater resources recovery owing to its outstanding performance in extracting volatile molecules. The orthogonal quadratic central composite model has been employed to optimize MD parameters for maximum and economical ammonia recovery from human urine. The feed urine pH, the permeate side acid concentration, feed flow rate, and feed temperature has been considered as an independent variable and kg of fertilizer (NH4)2SO4 per unit $/m3 of urine has been considered as a response. Accordingly, high-grade ammonium sulfate fertilizer has been produced and its economic viability has been compared with conventional production system which reveals that hollow fiber MD is a viable and economical alternative technology for fertilizer production from human urine. The study also modeled ammonia mass transfer process through MD membrane.

Urine Dehydration Technology for Recycling Nutrients in a Public Dry Sanitation System

Simha Prithvi, Jenna Senecal, Caroline Karlsson, Riikka Maila, Eeva Liisa Viskara, Björn Vinnerås

Urine is the main contributor of plant nutrients from the households and therefore holds great potential for recycling. The objective of this study was to scale-up a laboratory system that stabilizes and dehydrates urine to be then used as a fertilizer. A full-scale drying unit was installed in a public toilet with over 100 daily users. Methods: The unit was installed in a mobile structure and equipped with dehydrating medium having a pH >12 and operated for 3 months (March to May, 2019). Data collection included: user frequency, airflow, air moisture, temperature, change in mass of the drying containers, energy consumption, NPK concentration of the dehydration medium and pH. The study is ongoing and the results (such as user frequency, mass flows of water, N, P, K and energy consumption of the system) will be included in the paper presented at the conference. The discussion will consider the function of the system, the global potential and further development for full-scale implementation.

Enabling Resource Recovery by In-Sewer Treatment and Microbial Ecology-based Engineering: Water Re-Use Starts Now in the Sewer

Nouha Klai, Lisha Guo, Domenico Santoro, Dominic Frigon

The ability to control wastewater influent characteristics is an essential step in enabling the paradigm shift from conventional wastewater treatment plants to water resource recovery facilities, as well as to enable the recovery the most important resource: water. As a matter of fact, advanced control of wastewater influent characteristics not only guarantees an overall better effluent quality (in view of water recovery and reuse), but also enables two emerging resource recovery platforms such as “low energy mainline” (LEM) and the “partition, release and recover” (PRR) via specialized biomasses Anammox (for LEM, due to lower oxygenation requirement) and purple phototropic bacteria (for PRR, due to total nutrient assimilation). In this paper, we report the outcome of a full-scale genomic experimental study, supported by integrated modelling, carried out on a sewer connected to a wastewater treatment plant in Southern California, USA. In-sewer treatment by nitrate was carried out to achieve multiple treatment objectives, namely carbon reduction (by denitrification) and odour control (by sulfide removal). Genomic and modelling tools were used to probe, confirm and predict how the microbial community biochemical pathways would shift in presence of 70 mg/L nitrate dosing.

Session 8
ENHANCED ANAEROBIC TREATMENT
Room Auditorium

Enhanced Anaerobic Treatment as Core of the WRRFs: Pilot and Full Scale Experiences
Bruce Jefferson, Cranfield University (UK)
Transformation of sewage works from wastewater treatment facilities to resource factories that enable effective resource recovery require reconsideration of how we utilise biological processes. Specifically, a shift away from the aerobic biological technologies towards anaerobic alternative appears increasingly critical. The switch preserves the nutrient load within the wastewater for recovery, generates valuable products (methane), limits greenhouse gas emission whilst preserving, and perhaps enhancing, the potential for water reuse. In particular, the use of anaerobic membrane bioreactors (anMBRs) has gained attention as a core technology in the transformation towards resource recovery. The inclusion of the membrane helps enhance bioreactor resilience and produces an effluent stream free from solids and pathogens, and rich in nutrients. The development of flowsheets centred around anMBRs remains in its infancy with a limited number of demonstration and full scale sites. Key lessons can be learnt from these early developments that can enrich future endeavour and increase the potential to embrace resource recovery in future developments.

Efficient Utilization of Regional Biomass with Intensive Digestion System Using Sludge Solubilisation and Solid Oxide Fuel Cell
Manabu Matsuhashi, Ryoichi Maeda, Haruo Miyake, Yusuke Shiratori, Atsushi Tajima
Digester (500 m3) with sludge solubilisation facility and solid oxide fuel cell (SOFC) system was installed in a sewage treatment plant to demonstrate the intensive utilization of regional biomass wastes as energy resources. Superiority of this system in terms of life cycle cost (LCC), power consumption and power generation were evaluated. Compared to a conventional digester, LCC can be reduced by about 14.1% (considering the period after widespread dissemination of SOFC), and 22.1% increase in power generation can be achieved.

Innovative Ex-situ Biological Biogas Upgrading Using Immobilized Biomethanation Bioreactor (IBBR)
Katie Baransi-Karkab, Mahdi Hassanen, Sharihan Muhsein, Nidal Massalha, Isam Sabbah
Biogas, which typically consists of about 60-70% of methane gas, is produced by anaerobic digestion of organic waste and wastewater. Biogas is considered a potentially important energy resource; however, it has limited application and utilization. In this regard, upgrading it to natural gas quality (above 90% methane) can enable broad applications. In this work, we used novel ex-situ immobilized biomethanation bioreactors (IBBR) for biogas upgrading as a post treatment. The reactors contained immobilized microorganisms within a polymeric-based matrix. The innovative ex-situ biogas IBBRs showed promising results. CH4 content of 80-90% was achieved by reducing CO2 to CH4 (biomethanation) through supplying hydrogen gas as an electron donor outside the anaerobic digester.

High Rate Immobilized Anaerobic System Treating Wastewater - Evaluation and Simulation at a Pilot-scale System
Isam Sabbah, Daniel Dias, Jorge Ribeiro, Mahdi Hassanin, Morad Massalha, J. Santos, Nedal Massalha, Salva Shmulevich, Avi Aharoni, Adrian Oehmen
An evaluation and simulation of an Advanced high rate Anaerobic Treatment technology (AAT) system applied at demo-scale with focus on methane production was performed in Karmiel (Israel) WWTP. The reactor is composed of an impregnated active biomass foam matrix to guarantee process stability and increase biogas production efficiency while reducing OLR shocks. Two different scenarios were investigated,1st scenario: AAT preceded by a primary clarifier and; 2nd scenario: AAT received raw sewage. Average removal efficiencies were higher during the 2nd scenario, with biogas production at1.3 and 6.7 m3.d-1during scenario1 and 2, respectively. The ADM1 showed applicability for the AAT (COD and gas flow).

Free Nitrous Acid Pre-treatment of Waste Activated Sludge Enhances Efficiency and Rheological Behaviour of Anaerobic Sludge Digester

Jia Meng, Huijuan Li, Shoan Shrestha, Min Zheng, Haoran Duan, Jason Dwyer, Shihu Hu, Zhiguo Yuan

Previous laboratory studies demonstrated that, with FNA pre-treatment of Waste Activated Sludge (WAS), an anaerobic sludge digester can achieve higher (~30%) VS destruction and methane production at a shorter solids retention time, with a highly favourable economic outcome. This pilot-plant study not only confirmed the enhancing effect of FNA pre-treatment on VS destruction and methane production, but also revealed that FNA pre-treatment of WAS reduced the viscosity of digested sludge by 75%. It also saves the polymer requirement for dewatering by 24%. These benefits further enhances the business case of the technology.

Long Term Operation of Anaerobic Municipal Wastewater Treatment of Low-loaded Wastewater for Fertigation Purposes

Alessia Foglia, Çağrı Akyol, Anna Laura Eusebi, Giulia Cipolletta, Nicola Frison, Stefania Gorbi, Francesco Fatone

Anaerobic municipal wastewater treatment by UASB and AnMBR has been investigated at pilot scale in operational environment, aiming at reuse for fertigation purposes and focusing even on emerging contaminants such as microplastics (MPs). In AnMBR, 85% COD and 100% TSS removals were achieved as well as TN and TP releases from 75% to 85%. Therefore, the permeate could be suitable for fertigation. The removal of MPs in UASB was in the range of 40%-50%, while less than 0.1 MPs/L (100 MPs/m3) were found after AnMBR. In the last step, Ozone and Sodium Hypochlorite treatments were also conducted to verify their effects on MPs further to disinfection.

Non-ideal Mixing Model of Anaerobic Digestion: Linking the CFD Model and ADM1

Yohannis Mitiku Tobo, Jan Bartacek, Ingmar Nopens

Renewable energy (biogas) is one of the resources recovered from wastewater treatment facilities. Most of the anaerobic digestion (AD) kinetics model assume the digester as ideally mixed, however, non-deal mixing is more common in real AD operation. So far, a mathematical model connecting AD kinetics and CFD model has not been developed. In this work, the non-ideal mixing model of AD was developed by combining Computational Fluid Dynamics (CFD) and Anaerobic Digestion Model 1 (ADM1) using a compartmental model (CM) approach. The computed results showed that the biogas and methane production reduced by 14 and 16%, respectively, under non-ideal mixing compared to ideally mixed digester. Furthermore, the biomass and pH distribution are not uniform in non-ideally mixed AD opposing ideally mixed digester.

Exploring Forward Osmosis for Production of Reclaimed water and Concentrated Wastewater for Anaerobic Treatment

Federico Ferrari, Ignasi Rodriguez-Roda, Maijte Puijan, Gaetan Blandin

Forward osmosis (FO) is a promising technology for wastewater (WW) treatment due to its lower energy requirements, higher permeate purity and lower fouling. Applying FO directly on raw municipal WW is of high interest to simultaneously produce a high quality permeate for water reuse while pre-concentrating wastewater for anaerobic digestion towards energy and nutrients recovery. This bench scale study investigated the feasibility to concentrate real raw municipal WW using FO to reach 70% water recovery with a home-made submerged plate and frame membrane module, assembled using Toray's flat-sheet TFC membrane. Process showed high COD rejection and high differences in ion rejection depending on the charge (SO42-=99±2%, PO43--=99±2%, NH4+=17±4%, Ca2+=10±2%). Three different gas sparging strategies (continuous air sparging, alternating nitrogen sparging and no gas sparging) were tested to control membrane fouling, being the continuous air sparging the most favorable.

Long-term Performance of Two Pilot Scale Anaerobic Reactors for Thermal Hydrolyzed Sludge Digestion under Mesophilic and Thermophilic Conditions

Zhan Chen, Wei Li, Jiawei Wang, Xianghua Wen

In this study, the performance of two pilot scale anaerobic reactors that operated in parallel under mesophilic (MAD) and thermophilic (TAD) conditions for 368 days to treat thermal hydrolyzed sludge was evaluated. MAD was more appropriate for thermal hydrolyzed sludge digestion in terms of better performance in methane production than TAD. In contrast, methane production in TAD might be inhibited by ammonia

nitrogen, especially free ammonia, accumulation. Resulted from the two temperatures, microbial community composition displayed a great difference between MAD and TAD. The microbial community structure in MAD was more beneficial for methane production.

Intensifying Energy Recovery via Biological in situ Biogas Upgrading by Means of Hydrogenotrophic Methanogenesis in WWTP

Viola Corbellini, Francesca Malpei

In a circular economy context, anaerobic digestion (AD) of sewage sludge permit to recover energy in the biogas form and a further biogas upgrading process allows boosting this recover. The biologically-mediated biogas upgrading in which exogenous H2 is provided into an AD to couple with endogenous CO2 via hydrogenotrophic methanogenesis is gaining more and more attention. This study investigated biological in-situ biogas upgrading continuously fed on sewage sludge for 217 days. 2 parallel CSTRs (11L) at mesophilic conditions; organic loading rate (OLR) of 1.5 gCOD L-1d-1 and with H2/CO2 ratio progressively increased from 0:5:1 to 7:1 (OLRH2 0-0.4 gCOD L-1d-1 with pH controlled (7.4±0.2). Maximum methane content of 83% and a minimum of 5% of CO2 and 91% of H2 utilization were achieved at 7:1 H2/CO2 ratio. An ethanol accumulation, during first H2 Phase, occurred (2.5-3 gCOD L-1) but rapidly depleted. Furthermore, alkalinity reductions (50% and 17% in R1 and R2) registered indicated a possible in-situ constraint.

Full-scale Anaerobic Co-digestion of Sludge and Organic Waste: Rovereto Four-year Experience

Cristina Cavinato, Filomena Ardolino, Giovanni Gatti, Gian Paolo Mattuzzi, Franco Cecchi

Energy production from renewable resources can be integrated with waste management by means of the anaerobic co-digestion (ACoD) technology application. In urban contexts two of the most abundant organic refuses are sludge from wastewater treatment and organic fraction of municipal solid waste (OFMSW). This study reports a four-year full-scale co-digestion experience of mixed primary and secondary sludges and pretreated OFMSW applied in the Rovereto wastewater treatment plant (WWTP). Biogas production was equal to 7,000 m3/d and the electric energy production covered about 80-85% of the total energy requirements. Different sludge and OFMSW co-digestion approaches are compared both from an economic and environmental point of view.

Blend Quality and Logistics Optimization of Anaerobic Codigestion in a Real Multi-Plant Case Study

David Palma, Marta Verdaguer, Manel Poch, M.À. Cugueró-Escofet

Implementation of circular economy strategies is a must for sustainable development. Regarding water sanitation processes, maximization of anaerobic digesters capacity at WWTPs is a well-established strategy, known as co-digestion. Many optimization tools have been developed to optimize blend composition. However, associated logistics to each component of the blend remain as a relatively unexplored field, which can yield to significant planning problems. Here, an Ant Colony Optimisation (ACO)-based approach is proposed to tackle these problems. The proposed algorithm maximizes an objective function composed by: a first term, related to the quality of the sludge; and a second term, related to the distance between the sludge generator and the anaerobic co-digester. It is expected to provide a wider perspective by including logistics considerations in the solution provided, and thus to improve co-digestion planning strategies in a real case study composed of 16 WWTPs.

Session 9
VFA AND ORGANICS RECOVERY AND REUSE
Room 6

Cellulose Recovery and Carbon Upgrading by Integrating Microsieving and Fermentation Technologies in Wastewater Treatment Plants: A Plant-Wide Modeling Study
Santoro Domenico

In this work, the Benchmark Simulation Model no2 was extended to a resource recovery application by first extending the model with the incorporation of a rotating microsieving technology (Salsnes Filter) and, consequently, by tracking the fate of cellulose across the typical municipal wastewater treatment processes as an independent state variable. Separating in the BSM2 model cellulose, mostly in the form of particulate fibers, from other forms of particulates allows not only for precise mass balance in every location of interest of the plant, but also the exploration of seasonal impact due to the strong (non-Arrhenius) temperature sensitivity of the cellulose hydrolysis rate constant both in the anaerobic and aerobic processes. Different temperature dependency functions were needed for the hydrolysis of cellulose in the activated sludge unit and the fermenter/anaerobic digester. To determine the potential of carbon upgrading from a slowly biodegradable form (i.e., cellulose) to a readily available form (i.e., VFAs, etc.), hence helping carbon-limited denitrification and bio-P plants, we simulated the presence of a hydrolysis unit (fermenter) to utilize part of the cellulose from the influent in the form of readily available COD or denitrification. Scenario analysis has been performed in order to understand the impact of cellulose diversion under different operating temperatures and the impact of the new hydrolysis unit.

Volatile Fatty Acids Production: Effect of Bacterial Community Under Various Operational Conditions
Merve Atasoy, Zeynep Cetecioglu Gurol

In this study, various operational conditions and bacterial community were evaluated to enhance VFA production. Three different inoculums were operated under various pH and retention times by using glucose as a substrate. According to results the VFA composition changed by pH and retention time, whereas the production efficiency depended on the inoculum type. The highest VFA production efficiency (0,97 gVFA/gsCOD) was achieved under pH 10 on the fifth day. The dominant acid type was butyric acid (58%). The bacterial community was analysed by next-generation sequencing of 16S rRNA gene, which showed that 51,3% Clostridiaceae is the most dominant taxa in the samples.

Targeting Specific Volatile Fatty Acid Production through pH Shifts During Protein Fermentation
Riccardo Bevilacqua, Alberte Regueira, Miguel Mauricio-Iglesias, Marta Carballa, Juan M. Lema

There is very limited literature on the influence of pH on volatile fatty acids (VFA) selectivity from protein-rich substrates fermentation and available information is controversial. The objective of this work was to analyse the influence of pH (i.e. 5, 7 and 9) during the continuous mixed culture fermentation of two model proteic compounds (casein and gelatine) and to discern whether protein composition determines pH effect. Casein achieved higher acidification degrees than gelatin at all tested pHs. Moreover, VFA spectra noticeably changed with pH shifts, although the extent of the variations depended on the protein composition as well: acetic acid increases with pH values, n-butyric and n-valeric are linked to acid environments, while iso-valeric is favoured at alkaline pHs. In general, more reduced and valuable VFAs are produced at low pHs. This knowledge helps to better predict the outcome of protein-rich substrates fermentation and consequently drive it towards desired products.

Biorefinery Pilot Plant for VFAs and Nutrients Recovery from Agro-waste Material
Simone Nortilli, Edoardo Rigetti, Nicola Frison, David Bolzonella

The Horizon 2020 NoAW project aims the application of the circular economy approach by exploring the potential of agro-waste to be converted into a portfolio of eco-efficient products such as bio-energy, bio-fertilizers, bio-packaging and bio- molecules, in symbiosis with urban waste conversion. In this work, a biorefinery pilot plant was implemented in an Italian livestock farm (La Torre srl, Isola della Scala - Verona, Italy)

with the target to convert agricultural residues into VFAs building blocks through acidogenic fermentation. The pilot plant consisted of a fermentation unit fed with liquid manure and maize silage/grass residues, a screw-press separator and an anaerobic digester to valorize as biogas/biomethane the solid fraction from the solid/liquid separation. The enhanced solid/liquid separation of the liquid fraction through rotating ceramic membrane allows the potential recovery of VFAs and high quality of phosphorus based fertilizer from the fermentation liquid and anaerobic digestate respectively.

Pilot Scale Acidogenic Fermentation of Microsieved Cellulosic Sludge for Short Chain Fatty Acids Production

Cinzia Da Ros, Nicolas Frison, Vincenzo Conca, Anna Laura Eusebi, Francesco Fatone

In this work, cellulosic sludge was recovered from municipal wastewater by means of microsieving through pilot rotating belt filter and fed in a fermentation unit for Short Chain Fatty Acids production. According with loadings, the removal efficiencies varied between 17-76% for suspended solids and 10-61% for the COD, while less than 27% for nitrogen and phosphorus. The acidogenic fermentation of the CS was conducted initially in batch mode to evaluate the short chain fatty acids production yields at different pH. The higher value was obtained at pH 9 (521 mgCOD per g of volatile solids) while without any pre-treatment the yield was of 232 mgCOD per g of volatile solids. Then, a 2.6 m3 Sequencing Batch Fermentation Reactor was operated at 4 days of hydraulic retention time and mesophilic temperature (37°C). The VFAs production achieved were as high as 2.1 kgCODVFA/m3 day reactor, where up to 50% was propionate.

Direct Membrane Filtration of Municipal Wastewater by Ceramic Flat-sheet Membranes for Recovery of Organic Matter

Katsuki Kimura, Megumi Kato

Ceramic flat-sheet MF membranes were used for concentration and recovery of organic matter in municipal wastewater. The use of ceramic membrane allowed us to carry out intensive physical cleaning and chemical cleaning. Continuous 50-fold concentration of organic matter in municipal wastewater was possible with a ceramic membrane under the condition of relatively high fluxes. Recovery of organic matter reached >75%.

Hydrothermal Carbonization of Sewage Sludge: Process Optimization by Response Surface Methodology

Monica Puccini, Andrea Tasca, Gemma Mannarino, Anna Raspolli Galletti, Sandra Vitolo, Riccardo Gori

Hydrothermal carbonization (HTC) may be considered a promising process for the conversion of sewage sludge into valuable products such as fuel, sorbent materials or amendment. In this study the optimization of HTC of sewage sludge from urban wastewater treatment was conducted by using the Response Surface Methodology (RSM) approach for studying the effects of temperature, residence time and solid content loading. The hydrochar produced by hydrothermal carbonization of sewage sludge under different reaction conditions was characterized in term of physical, chemical, and morphologic properties. The HTC process enhanced dewaterability, higher heating value and C content of the raw material, offering a promising alternative in the management of sewage sludge.

Pretreatment and Process Optimization for Brewery Spent Grain Conversion into Chemical Building Blocks

Juan Castilla-Archilla, Stefano Papirio, Piet N.L. Lens

Food-agricultural wastes have significant potential for use in a circular economy. Hemicellulose and lignocellulose represent the most abundant source of carbohydrates for bio-industrial purposes, but their complex nature results in a low biodegradability. The present work investigates the use of brewery spent grain as a valuable substrate for the production of volatile fatty acids (VFAs), alcohols and lactic acid. Firstly, a thermal diluted acid hydrolysis of the substrate was performed. Then, acidogenic fermentation of the liquid fraction was carried out at 37°C and different pH (uncontrolled, 4.5, 5.0, 6.0 and 8.0), using anaerobic granular sludge as inoculum. The highest VFA concentrations were observed at pH 6.00 (± 0.05), with 16.89 (± 1.33) gCOD/L.

Selective Separation of Organics and Inorganics by Ion-Exchange Membranes

Lingshan Ma, Leonardo Guiterez, Muhammad Waqas, Emile Cornelissen, Marjolein Vanoppen, Arne Verliefde

This study contributes to the field of selective organics/inorganics separation using ion-exchange membrane (IEM) technologies (i.e., electrodialysis, reverse and assisted-reverse electrodialysis) in the treatment and resource recovery of organics-rich industrial wastewater. The diffusive and convective transport of uncharged (i.e., phenazone, paracetamol, and theophylline) and charged organics (i.e., clobifric acid and atenolol) in IEMs were investigated in diffusion cells. The transport of uncharged organics in the absence of salt was purely diffusion-driven, while the presence of salt had a slight influence on the transport of organics (<5% transported mass difference). However, other mechanisms play a role in the transport of charged organics, as their transport was not constant with the absence of salt, and the presence of salt in the receiving solution highly promoted the transport of organics (by 59% transported mass higher for clofibric acid) while inhibited their transport when the salt present in the feed (by 13% transported mass lower for clofibric acid). The observation could indicate that convective transport is limited while electromigration was playing a dominant role. The experimental validation of the solution-diffusion model showed that the model underestimated the uncharged solutes transport in IEMs.

Pathogen Inactivation and Resource Recovery from Sanitation Waste Through In-situ Accumulation of Carboxylic Acids

Lauren Harroff, Janice Liotta, Dwight Bowman, Largus Angenent

Through lab-scale and pilot-scale trials, we have developed a bioprocess that utilizes open cultures of anaerobic bacteria to ferment human fecal material (HFM) and accumulate carboxylic acids. The process requires only inputs of HFM and carbohydrate-rich food waste, which reduces the pH within the bioreactor to keep carboxylic acids in the undissociated form that is toxic to pathogens. In a pilot-scale trial with 45-L batch containers, we produced 43.1 mM n-caproate, with 13.1 mM in the undissociated form. We also demonstrated successful pathogen inactivation in this system using Ascaris eggs as indicators. This process inactivates pathogens and initiates biological degradation of HFM, leaving a product that is primed for further conversion into value-added products such as biogas and black soldier fly larvae.

Impact of Advanced Separation Technologies on the Fermentation Products of Municipal Sludge

Antoine Brison, Nicolas Derlon

Anaerobic digestion without biogas production is a relevant approach for the valorisation of organic substrates. We evaluated fermentation of particulate organic matter (POM) captured using a conventional primary settler as opposed to advanced technologies such as micro-sieving and the high-rate activated sludge (HRAS) process. Our results demonstrate that volatile fatty acids (VFAs) are the main fermentation products whatever the origin of the POM, and that all fermentates are thus suitable for polyhydroxyalkoanoate (PHA) production. Also, the POM composition governs the composition of the produced VFA cocktails; protein rich HRAS for example yields higher fractions of longer-chained acids. The average conversion yields of POM to VFAs however, did not exceed 0.3 gVFA,COD gVSS,fed-1. High-pressure thermal pre-treatment of POM is thus considered to reduce rate-limitation by hydrolysis and further increase VFA production rates.

Anaerobic Co-digestion of Sewage Sludge and External Organic Waste: Strategy to Shift Production from Biogas to Volatile Fatty Acids

Isaac Owusu-Agyeman, Ezbieta Plaza, Zeynep Cetecioglu

Volatile fatty acids (VFAs) have higher value and wider usage range than biogas. The study sought to devise strategy to shift anaerobic digestion production from biogas to VFA by systematically investigating the impact of substrate ratio of sewage sludge and external organic waste (OW). Co-digestion was carried out in batch reactors of 500 mL volume, at pH 5 with OW proportion of 0%, 25%, 50%, 75%, 100%. VFA production increases with increase in the percentage of organic waste in the influent due to the availability of higher biodegradable organics. The volume of biogas produced decreases with increase in organic waste percentage in the substrate and was explained by different kind of VFA formed by the two substrate and the inhibitory effect of high VFA concentration.

Session 10
BIOPOLYMERS AND VALUE-ADDED PRODUCTS RECOVERY: NOVEL TECHNOLOGIES

Room Theatre

Valorisation of Complex Wastewater for the Production of PHA

Alba Roibás-Rozas, Lucia Argiz, Alba Predouso, Angeles Val Del Rio, Almudena de Hospido, Anuska Corral Mosquera

A two-stage system was operated to produce polyhydroxyalkanoates (PHAs) using complex wastewater, with high concentrations of sodium chloride, ammonia and proteins. In a first anaerobic reactor, organic matter was transformed into Volatile Fatty Acids (VFAs). A second reactor was fed with this VFA-rich stream to enrich the system in halophilic PHA accumulating bacteria. Adding small amounts of NaHCO3 (from 20 to 360 mg/L) to the feeding of the anaerobic reactor, pH remained stable in values around 4.5, hence higher VFA concentrations were achieved, and higher organic loading rates could be imposed to the enrichment reactor. Under these conditions, the concentration of accumulating biomass increased and higher accumulation capacities (from 7.5% to 32.8%), productivities (from 14.31 to 48.20 mg PHA/(g biomass·h)) and PHA concentrations (from 0.10 to 2.00 g PHA/L) were achieved.

Recovery of ALE (Alginate-like Exopolymer) from Aerobic Granular Sludge and Application as Phosphorus Adsorbent

Patricia Dall´Agnol, Nelson Libardi, Jessica Xavier, Rejane Helena Ribeiro Da Costa

This work aims the recovery of ALE (alginate-like exopolymer) from aerobic granular sludge and its application as phosphorus adsorbent in liquid samples. The solution pH, adsorbent mass, temperature and initial phosphorous concentration were tested through the factorial experimental design to determine the best adsorption conditions. The ALE yield of 21% was recovered from aerobic granules. The highest phosphorus removal efficiency (72.8%) was achieved using solution pH of 8.0, initial phosphorus concentration of 100 mg/L and adsorbent mass of 0.158 g at 45 °C. The highest adsorption capacity (57.7 mg/g) was achieved using lower ALE beads mass (0.016 g).

Optimization of a PHA Production Process with Nitrifying surplus Activated Sludge Via Dissolved Oxygen Control

Angel Estevez-Alonso, Ruizhe Pei, Robbert Kleerebezem, Mark van Loosdrecht

When surplus activated sludge is directly used for PHA production from fermented organic streams that often contain excess ammonia, nitrifying bacteria could challenge the process performance (oxygen and alkalinity consumption). It has been hypothesized that low dissolved oxygen concentration (DO) can be used for partially limit nitrification while maintaining the PHA production rate. However, previous research was unable to effectively limit nitrification when working at low DO. Here an evaluation of the influence of the Monod affinity constant for oxygen under different DO was carried out. Limitation of nitrifying activity without affecting PHA production was predicted when PHA accumulating bacteria showed higher apparent affinity compared to nitrifiers. Simultaneous nitrification denitrification could be used to partially maintain the PHA production process under low DO, however longer accumulation times are predicted to be required. The model promises to be a tool towards establishing optimal dissolved conditions in industrial process with accumulating PHA biomass compounded by active nitrifiers.

Influence of Wastewater Composition and Bioaggregates Types on the Properties of Alginate-like Exopolymers

Cássio Moraes Schambeck, Lukas Boni, Peter Fischer, Elisabeth Girbal-Neuhauser, Yolaine Bessière, Paul Etienne, Rejane Helena Ribeiro da Costa, Nicolas Derlon

This work assessed the influence of wastewater (WW) composition and bioaggregates types on the content, chemical and gelling properties of alginate-like exopolymers (ALE). Results indicated that the WW composition/

bioaggregate type have limited influence on the ALE content. ALE was mainly composed of proteins, humics acids and uronic acids. Only the ALE extracted from granules fed with acetate/propionate featured mannuronate content. ALE extracted from bioaggregates fed with real WW had high humic acids content. All extracts were suitable to form gels, what is attributed to the presence of uronic acids. The rheological properties of the gels were directly influenced by the composition of the ALE extract: ALE from granules fed with soluble COD had the highest and from activated sludge fed with real WW the lowest storage modulus G'. Linking growth conditions to the gel properties is relevant for full-scale recovery of ALE and its industrial application.

Biopolymers Recovered from Waste Anammox Granular Sludge as Paper-Coating Additives to Enhance Water and Grease Resistance

Cuijie Feng, Tommaso Lotti, Francesca Malpei

The waste sludge, like granular sludge, produced from wastewater treatment processes, is considered as a waste product. Extracellular polymeric substances recovery from anammox granular sludge provides a renewable resource for waste sludge recovery. The results in this paper show that by using renewable biopolymers as paper agents, the water and grease resistance performance of coated paper can be improved.

Extraction and Characterisation of Polyhydroxybutyrate Biologically Synthesised Using Mixed Microbial Cultures

Dario Presti, Gabriella Montiel-Jarillo, Diego Morales-Urrea, Giorgio Mannina, Edgardo Contreras, Julián Carrera, María Eugenia Suárez Ojeda

In this work, the effectiveness of several chemicals for polyhydroxybutyrate (PHB) extraction from mixed microbial cultures (MMC) was established. The enriched PHB-producing MMC used acetic acid as precursor. The tested chemicals were: the green solvent dimethyl carbonate, the switchable anionic surfactant NH4-laurate, the surfactant sodium dodecyl sulphate and the base NH4OH. All chemicals were tested on lyophilized biomass containing PHB. Moreover, their efficiencies were compared to chloroform, which is used regularly at lab scale for bioplastic extraction. The highest recovery yield and purity (74±8 % and 100±5%, respectively) were obtained when using NH4-laurate for which operating conditions of the extraction process such as temperature, concentration and contact time were optimized.

Impact of Influent Suspended Solids on Granulation and Production of Gel-forming Polymers in an Aerobic Granular Sludge Reactor Treating Brewery Wastewater

Flinn De Vleeschauwer, Michel Caluwe, Jan Dries

Gel-forming alginate-like extracellular biopolymers (ALE) contribute to aerobic granular sludge (AGS) formation and stability. This study investigated the impact of influent suspended solids on AGS formation and ALE production in an anaerobic/aerobic AGS reactor fed with brewery wastewater. The presence of suspended solids did have a significant impact on the ALE production and AGS formation. Whereas the AGS was more hybrid like and had a ALE MLSS content of around 10% when feeding influent with suspended solids (±233 mg/L), complete granulation was achieved when the influent suspended solids were removed. Furthermore the ALE MLSS content increased to around 30%.

Extracellular Polymeric Substances (EPS) From Anammox Granular Sludge as Biosorbent for Heavy Metals Removal

Benedetta Pagliaccia, Tomasso Lotti, Emiliano Caretti, Mirko Severi, Deborah Berti, Claudio Lubello

The excess sludge is a waste, whose costs of handling/disposal represent up to 50% of the wastewater treatment operative costs. Anammox-based technologies allow reducing the excess sludge production. In addition, the recovery of biomaterial from excess sludge to be applied in other industrial sectors would increase the environmental and economical sustainability of wastewater treatment. This study investigated the application of Extracellular Polymeric Substances (EPS) recovered from Anammox granular sludge as bio-adsorbent material for the removal of heavy metals. The high adsorption capacity of EPS observed for heavy metals such as Zn, Ni, Cu and Pb was used for the development of an efficient adsorbent material in combination with granular activated carbon.

Exploring Resource Recovery Potentials for the Aerobic Granular Sludge Treatment Process

Philipp Kehrein, Mark van Loosdrecht, Patricia Osseweijer, Jo de Wulf, Marianna Garfi, John Duque Posada

This study uses material and energy flow analysis to model seven different process designs that integrate resource recovery technologies into the aerobic granular sludge treatment process. The trade-offs between COD recovery as energy and biopolymers, and between phosphorous as struvite and as ash-P are quantified. It is shown that energy recovery from COD by anaerobic digestion is preferable over sludge incineration and can be optimized through COD up-concentration. Moreover, COD recovery as biopolymers decreases the potential for energy and P recovery. The results may support decision making in conceptual WWTP process designs that aim for enhanced resource recovery from aerobic granular sludge treatment processes for municipal wastewater streams.

Recovery Potentials from Aerobic Granular Sludge Treating Low C/N Real Municipal Wastewater

Riccardo Campo, Emiliano Carretti, Debora Berti, Simone Caffaz, Claudio Lubello, Tomasso Lotti

In this study, aerobic granular sludge process was applied to real municipal wastewater originating from combined sewer system. A fully granular bed was obtained thank to a novel control strategy resulting in optimal effluent quality, 60% of nitrogen removed via-nitrite and a low observed yield(0.21±0.01gCODx/gCOD). Extracellular polymeric substances recovered from the excess granular sludge produced were evaluated as soil conditioner in agriculture in the form of hydrogels. The effect of polymer extraction was studied in view of the anaerobic digestion of the remaining sludge.

Session 11
ECONOMIC AND ENVIRONMENTAL SUSTAINABILITY ASSESSMENT

Room 6

Evaluating Construction Industry Views on Recovered Cellulose as a Component of Building Materials

Elaine Gallagher, Caitriona Shannon, Heather Smith

The construction sector is under increasing pressure to adopt more sustainable products and materials. However, the adoption of new technologies and processes can be risky and complex, with a variety of potential concerns and challenges. Cellulose recovered from wastewater can be used in building materials – namely insulation, asphalt, and polymer composites – to replace certain existing components and help drive down the overall carbon footprint of the construction industry. However, it is unclear how well this innovative material might be accepted and what kinds of concerns those within the construction industry might have about its use. The current study used an online survey, targeted at construction and development professionals, to evaluate perceptions, expectations, and factors which impact the uptake of recovered cellulose materials. Overall, preliminary findings show a support for the use of these materials, however factors such as cost were identified as being a key driver of adoption.

The Sustainability of Microbial Protein as Feed Ingredient – a Comparative Life Cycle Assessment of Three Growth Metabolisms with Soybean Meal

Marc Spiller, Maarten Muys, Myrsini Sakarika, Gustavo Papini, Matthias Buyle, Siegfred. E. Vlaeminck

The EU is calling for the production of sustainable and local protein sources, to replace for example soybean-based feed protein. Microbial protein is one option for this, but life cycle assessment studies are lacking. This research shows that dried microbial biomass produced on potato wastewater can be more sustainable (with the exception of fossil depletion) than soybean meal. This is however dependent on the source of soybean meal due to the environmental impact of land use change.

From Waste to Self-healing Concrete: A New Value Chain for Polyhydroxyalkanoates

Chris Vermeer, Emanuele Rossi, Robbert Kleerebezem, Henk Jonkers, Jelmer Tamis

Using mixed microbial cultures for the production of waste-derived polyhydroxyalkanoates (PHA) is a cost-effective and sustainable method to recover secondary resources. However, large scale application of PHA as a biodegradable plastic is restricted by expensive downstream processing and fluctuating physicochemical characteristics of the produced polymer. To overcome these challenges, the application of waste-derived PHA for the production of self-healing concrete is proposed. A proof-of-concept is provided where waste-derived PHA appears to be a suitable organic substrate which can induce self-healing activity similar to current technologies. Successful implementation of this concept will facilitate a breakthrough of both waste-derived PHA technology, as well as environmental friendly and affordable substrates for self-healing concrete.

Cost of Sericin Recovery from Silk Effluents

Tolga Pilevneli, Merve Gencturk, Ulku Yetis, Goksen Capar

Sericin protein is degummed from the silk fibre prior to dyeing and discarded as a waste in textile industry. The price for dry sericin ranges from €40/kg up to €100/gr. In this study, the cost of sericin recovery is calculated for a silk degumming facility via membrane hybrid processes at pilot scale. The total cost for recovering 1 kg dry sericin is found as €175. By recovering ethanol, which is used to precipitate sericin in membrane-concentrated wastewater, and increasing plant scale, it might be possible to reduce the cost of sericin recovery to competitive levels.

Integrated Sustainability Assessment of Wastewater Treatment Plants as Local Energy Suppliers

Peter Lichtenwoehrer, Florian Kretschmer, Guenter Langergraber, Georg Neugebauer

Wastewater treatment plants can take a new role as local energy suppliers, providing excess energy in the form of thermal energy, electricity and/or biogas. In order to sustainably provide excess energy, a holistic assessment methodology, in the form of an integrated sustainability assessment, is developed. Sustainability indicators were defined and incorporated on multiple levels, using a hierarchical approach. The practical application is currently carried out in five locations across Europe in order to guarantee the feasibility of the methodology for decision-makers and practitioners.

Developing A Market Place for Water in the Circular Economy: The NextGen Approach

Christos Makropoulos

NextGen aims to boost sustainability and bring new market dynamics throughout the water cycle at different demo cases and beyond. Moreover, it adresses social and governance challenges to ensure long-term adoption and support for circular economy solutions. This includes social acceptability testing, policy and regulation support and development of a future European Roadmap for Water in Circular Economy.

Comparative Cost Estimations Of Full-scale Phosphorus-recovery Processes In German Wastewater Treatment Plants

Lea Conzelmann, Fabian Kraus, Christian Remy

Due to a new legislation on sewage sludge disposal, phosphorus (P) recovery becomes obligatory for larger wastewater treatment plants (WWTP) in Germany from 2029 onwards. The new legislation requires that either sludge has a P-concentration below 20 g P/kg DM or a P concentration reduction of 50 % for sludge and 80% for mono-incineration sludge ash. The present study shows the costs and benefits of phosphate recovery from wastewater. Therefore, all relevant costs and savings are presented from an operator's point of view. The results show that the economics highly depend on initial conditions like plant size, P-concentration in sludge or ash, and the market value of the P-product. But they also depend on process specific conditions like energy and chemical costs and savings due to possible operational benefits such as credits for higher biogas yields or reduced sludge/ash disposal costs.

Thermal Energy Recovery Within Sewage Treatment Process

Marco De Sanctis, Valentina Piergrossi, Guido Valerio Altieri, Sabina Rosiek, Francisco Portillo, Francisco Javier Battles, Javier Martinez Del Rio, Iñaki Acasuso, Claudio Di Iaconi

It is widely accepted that fossil fuels are related directly to land and water degradation and global warming mainly as a consequence of greenhouse gas (GHG) emissions generated by anthropogenic activity. This explains the great attention paid to renewable energy sources during the last years. Urban wastewater is

a valuable source of clean energy that can be used both for building conditioning and hot sanitary water production, thus reducing primary energy demand and greenhouse gas emissions. In the present study, the integration of a highly efficient solar-assisted fully off-grid water-source heat pump (SHP) with an innovative biological system is tested for recovering and reusing thermal energy generated during the depuration process.

Drinking Water Distribution Networks: An Emerging Resource for Thermal Energy Recovery

Jawairia Imtiaz Ahmad, Sara Giorgi, Ljiljana Zlatanovic, Gang Liu, Gertjan Medema, Jan Peter Van Der Hoek

Drinking water distribution networks (DWDNs) have huge potential and significance for thermal energy recovery in the form of cold. This can provide enough cooling for buildings and spaces with high cooling requirements and is helpful in reducing carbon footprints by abandoning traditional cooling methods. This study showed that recovery of cold from microbial safe water of high quality by heat exchangers, at temperatures of 15, 25 and 30 °C after the heat exchangers, provided 54, 225 and 317 PJ/y of energy respectively. Furthermore, in subsurface the temperature of water within DWDNs, after having passed the heat exchanger, will be equivalent to surrounding soil temperature within 1km. From human health perspectives, opportunistic pathogenic bacteria like Legionella will not regrow after cold recovery at these three temperatures.

Waste-to-Resource Transformation – Computer-aided Systems Modelling of Waste Resource Recovery

Miao Guo

Wastewater (WW) and organic fraction municipal solid waste (OFMSW), represent carbon and nutrient rich resources composed of complex compositions like carbohydrates, lipid, protein, cellulose, hemicellulose and lignin. In conventional waste management value chains, OFMSW and WW components have been regarded as by-products as opposed to promising resources with energy and nutrient values. Full exploitation of waste resources calls for a value chain transformation towards proactive resource recovery and waste commoditization. This requires robust projection of OFMSW and WW composition and supply variability as well as waste recovery systems planning. Gradient boosting models were developed using historical socio-demographic, weather and waste data from UK local authorities. By integrating machine learning techniques with chemical process design and mathematical optimisation, our research highlights a systems modelling approach to inform decision-making on waste-to-resource transformation.

Session 12
ROAD TO BIOREFINERY AND WRRF IMPLEMENTATION

Room Auditorium

Full Scale Biorefinery and Territorial Strategy for Resource Recovery and Reuse: The Case of CAP Holding Italy

Andrea Lanuzza

Resource recovery needs territorial strategies rather than single projects. Gruppo CAP defined and is implementing a master plan focused on the optimization of its “network” of assets in order to optimize the engineering of its future biorefinery, also the value chain and maximize the resource recovery efficiency. Digital solutions will enhance productivity thanks to the collaboration with other utilities.

Compounds of Interest in Wastewater from Food Processing Industries: H2020 AFTERLIFE Project

Andrea Martos Dominguez, Santiago Perez Rodriguez, Nicola Frison, Maria Lopez Abelairas

Water is an indispensable resource and for this reason, management strategies should be adjusted to the sustainable development concept. Human activities, such as food processing, generate a high volume of wastewater that should be treated before being discharged to remove organic matter and nutrients that

can cause environmental damage. Despite the interesting potential of many of these compounds (proteins, sugars, lipids...) as raw materials for bio-based industry, their valorisation is currently limited, with the best technologies on stream, to the production of bioenergy. AFTERLIFE project develops an innovative wastewater treatment consisting of a low-fouling filtration system to recover all the solids in wastewater, which will suffer a supercritical/subcritical fluid extraction for the recovery of the value-added extracts. The rest of the organic matter will be converted into a high-volume added value biopolymer, polyhydroxyalkanoates, by means of a two-step-fermentative process

CoRe Water: From WWTP to a Sustainable Water and Resource Factory

Kees Roest, Julian Sierra Muñoz, Lex van Dijk, Annie Polman, Hans Ramaekers, Alexander Hendriks, Emile Cornelisen

How does wastewater treatment in the future look like? In the CoRe Water concept wastewater treatment will be fundamentally different from current practice. This innovative treatment concept consists of two steps. In the first step the wastewater is concentrated by a factor of twenty or more by means of membrane filtration. Subsequently the valuable components in the concentrated stream (one of the twenty parts) are recovered in several steps, the remaining nineteen parts can be reused as pure water after further treatment. The CoRe Water concept represents a highly innovative and disruptive approach of the treatment of wastewater, and aims to (1) bring about the reuse of water and valuable raw materials, (2) reduce greenhouse gas emissions, (3) significantly reduce the emissions of organic micro-pollutants like pharmaceuticals and (4) stimulate a compact and modular construction in wastewater treatment. In this presentation the current progress of our CoRe project, including applied pilot research at an existing sewage treatment plant, will be presented.

Chemically Enhanced Primary Treatment: Shall We Pay More Attention to Bio-sourced Coagulants to Maximize CH4 Production?

Florent Chazarenc, Fatima Ezzahraa El Messaoud

One way to advance proceed towards an energy efficient wastewater treatment plants is to maximize the capture of organic matter further valorized through anaerobic digestion, rather than oxidation or extensive bioconversion processes. The chemically enhanced primary treatment (CEPT) represents a well-known technology enabling to redirect as much as 40% of inlet carbon as biomethane. In this context, the main objective of this study is to evaluate the efficiency of new chemical and bio-sourced organic coagulants compared to the conventional FeCl3 focusing on removal mechanisms, their impact on carbon capture performances and bio-methane production. A decision matrix was developed to select the best performing coagulants based on their removal efficiency (jar test), biodegradability, and price. The preliminary results show that FeCl3 and Tannin have different actions on molecules according to their molecular masses, investigations are ongoing to better understand the removal mechanisms associated to each coagulant

Water Recovery and Reuse, Between Opportunities and Barriers: The Integrated Fusina Project (PIF)

Patrizia Ragazzo, Cristiano Franzoi, Andrea Razzini

Integrated Fusina Project (PIF) is a multifunctional platform for wastewater treating and multiple water reuse, developed for the Venice lagoon protection-valorization and the Porto Marghera area reclaiming.

Enabling Next Generation Resource Recovery

Julian Sandino, Samuel Jeyanayagam

This paper reports the findings of a Water Environment & Research Foundation (WE&RF) – funded project (Khunjar, et al., 2017) examining the next generation resource recovery form wastewater. Four product groups were investigated: volatile fatty acids (VFAs), polyhydroxyalkanoates (PHA), alcohols, hydrogen peroxide, and sodium hydroxide. VFAs are used for the production of PHAs, hydrogen peroxide, and sodium hydroxide. Therefore, evaluation of and improvements to VFA production serve as a gateway to recovery of higher value products. The value of hydrogen peroxide and caustic solution make both products appear attractive. This work is important for three reasons: (1) It provides water resource recovery facilities (WRRFs) the full menu of options for carbon management; (2) It continues to shift the perception of wastewater from a liability to a resource; and (3) It identifies technological and/or economic barriers, which are likely to spur future research efforts.

Upgrading of a Wastewater Treatment Plant to Resource Recovery

Dines Thornberg, Nick Ahrensberg, Jeanette Agertved

The shift from conventional wastewater treatment towards resource recovery facilities has become a priority focus in Denmark. In Copenhagen BIOFOS is heading a project that will introduce a multitude of activities towards a resource recovery facility at Avedøre wwtp (350.000 PE). A lighthouse project called VARGA is paving the way to more energy production, reduction of greenhouse gasses and recovery of phosphorus and concrete material from sewage sludge ashes.

Using Monte Carlo Based Simulation Optimization for the Design and Optimization of Wastewater Resource Recovery Facilities

Resul Al, Chitta Ranjan Behera, Gürkan Sin

Available treatment and separation technologies for wastewater are steadily expanding as the industry is undergoing a major paradigm shift toward a strengthened interest in resource recovery in the forms of both scarce materials and energy with tighter environmental regulations gradually put in place for allowable effluent discharge limits. Therefore, the problem of how to synthesize a wastewater resource recovery facility (WRRF) for a given influent has become more challenging than ever. With the purpose of addressing this problem with more systematic approaches borrowed from process systems engineering discipline, we proposed a novel Monte Carlo simulation-based superstructure optimization framework, which guides decision-makers to systematically synthesize and design plant layouts for WRRFs given influent pollutant loadings and desired design objectives. Provided by its in-house developed simulation-based optimization solver coupled with Monte Carlo simulations, the framework also enables engineers to optimize the design and operational decisions under uncertainty considerations using arbitrarily complex non-linear mechanistic process models. Finally, the framework also provides parallelization workflows to speed-up the required computational times and insightful data visualizations to assist decision-makers.

Hydrothermal Carbonization as a Suitable Process for Resource Recovery and Enhancement of Biogas Production from Sewage Sludge

Gemma Mannarino, Monica Puccini, Andrea Salimbeni, Massimo Aiello, Simone Caffaz, Riccardo Gori

Hydrothermal carbonization is a relatively new alternative for sewage sludge management. The aim of this work was to study the integration of HTC and wastewater treatment plants. The San Colombano plant (Florence, Italy) was selected as case study. Anaerobic digestion is here proposed to recovery of energy from the liquid fraction, obtained as a by-product of sewage treatment using HTC. For this objective, the process water from carbonization tests carried out on San Colombano plant's secondary sludge was firstly chemically characterized. Then, the San Colombano plant was modelled, considering the process water as a new input in AD. The model resulted in an enhancement of biogas production, indicating anaerobic digestion as a suitable process to increase the sustainability of HTC process for sewage sludge treatment.

Micro-sieving of Municipal Wastewater Improves Effluent Quality Energy Balance and Clarification Capacity of WWTPs

Nicolas Derlon, Ken Lüding, Markus Behl, Benno Maissen, Tobias Krast, Simone Buetzer, Alexandra Fumasoli

We evaluated the recovery of organic carbon from municipal WW using a drum screen, and its conversion into energy. The performances of the drum screen, the quality of the treated WW and the net energy balance were evaluated for two parallel treatment lines on a full-scale WWTP: without primary settler (control line) and with drum screen (experimental line). Solids removal of 67 ± 18% and 88 ± 7% were achieved with the drum screen alone or combined with flocculant, respectively. Energy consumption could be reduced by 13% while energy production could be increased by 70% with a drum screen alone. Also, the use of flocculant would help reducing the energy consumption by 25% while increasing the energy production by 125%. Effluent quality in terms of organic compound was improved, but deteriorated in terms of nitrates/ortho-phosphates, thus requiring adaptation of the operating conditions (recirculation rate). Clarification capacity was augmented due to the reduced biomass concentration and despite deterioration of the sludge settling properties. Overall, our study provides relevant insights about the full-scale implementation of drum screen for carbon recovery/conversion, and its implications on the whole treatment line.

Session 13
SMART PLANT SESSION
Room Theatre

Recovery and Valorisation of Cellulose from Wastewater - The Road to Circularity
Pim Marcellis, Coos Wessels, Carlijn Lahaye

Municipal wastewater contains high amounts of cellulose fibre (30–50% of the total suspended solids) that is mainly originated from toilet papers. Cellulose harvesting is expected to have added benefits to the WWTP's downstream biological process and provided outside the WWTP for the downstream blending with PHA and processing for final biocomposite production. SMARTech1 (SMART-Plant Technology) comprises an innovative integration of dynamic fine-sieving together with in-situ post-processing that is currently validated in the municipal WWTP of Geestmerambacht, Netherlands. CirTec has developed flow scheme with filter for primary treatment and separating cellulosic fibres to produce a highly-concentrated sludge.

Exploring the Integration of EBPR at Low SRT and DO in an A-stage System for COD and P Removal
Claudio Scalia, Congcong Zhang, Giorgio Mannina, Albert Guisasola, Juan Baeza

A novel high-rate A-stage WWTP configuration is proposed combining enhanced biological phosphorus removal (EBPR) and short SRT operation for the treatment of urban wastewater. The objective of an A-stage is removing as much COD as possible to redirect it to biogas production, while N is removed by a posterior B-stage with autotrophic processes. Considering our experience studying EBPR at low SRT, this work explores the possibility to integrate EBPR in an A-stage with an anaerobic/aerobic continuous configuration. Main key operational points for the success of this configuration are working at enough SRT and DO to maintain PAO activity while avoiding nitrification. Long-term operation data indicate that the operation is possible although the appearance of sporadic nitrification can compromise the stability of the system due to some nitrate leakage to the anaerobic reactor.

Nitrogen Removal via Nitrite from Thermally Hydrolysed and Digested Reject Water
Evangelos Statiris, Constantinos Noutsopoulos, Daniel Mamais, Nikolaos Petalas, Simos Malamis

A pilot-scale SBR was applied in order to treat reject water produced after dewatering of hydrolyzed and digested sludge. The system operated by implementing the nitritation/denitritation process achieving 88.6±6.2% and 71.0±19% NH4-N and TN removal respectively during the period with the higher nitrogen loading rate. During the examined period the SBR biomass was used in ex-situ tests in order to investigate the FNA inhibition on ammonia oxidation rates. These tests unveiled 50% inhibition at pH 7, 7.5 and 8 for FNA concentrations equal to 0.05, 0.04 and 0.035 mg HNO2 L-1 respectively. Similar experiments in a non-acclimated in FNA biomass showed that significantly lower concentrations of FNA (0.04, 0.017, 0.010 mg HNO2 L-1) can decrease the ammonia oxidation rates for 50%.

Modelling of a Novel Side-stream Technology Combining Short-cut Nitrogen Removal and Bioplastic Recovery
João Ribeiro, Vincenzo Conca, Jorge Santos, Daniel Dias, Nilay Sayi-Ucar, Cinzia Da Ros, Adrian Oehmen

This work focusses on extending the ASM3 model towards the description of short-cut nitrogen removal and simultaneous polyhydroxyalkanoate (PHA) recovery and the subsequent model application to describe this process currently operated at the pilot-scale in Carbonera, Italy. Results indicated that the calibrated and validated model could describe well the nitritation process, coupled with the aerobic feast/anoxic famine process for the selection of PHA producing organisms. The model will also be applied to test alternative operational strategies designed to maximise PHA recovery.

Trade-offs Between Environmental and Operational Parameters in SCENA Process
Vasileia Vasilaki, Vincenzo Conca, Nicola Frison, Francesco Fatone, Evina Katsou

The goal of the study was to assess the dynamic environmental performance of implementing full-scale side-stream nitritation-denitritation treatment of anaerobic supernatant at a real municipal WWTP in Italy. The trade-offs between process efficiency, energy consumption and greenhouse gas (GHG) emissions under

different operational conditions were investigated. Changepoint detection and timeseries outlier detection techniques were applied to link operational conditions with elevated dissolved N2O concentration and energy consumption. Abnormal behaviour of the system was linked with low availability of carbon source and anaerobic supernatant. This methodology can be used to assist researchers and operators to track and limit GHG emissions and energy consumption at wastewater treatment processes, integrating crucial environmental variables into process monitoring.

Environmental Technology Verification of the Full-Scale Short-Cut Enhanced Nutrients Abatement (SCENA) Process

Vincenzo Conca, Nicola Frison, Cinzia Da Ros, Matteo Tartini, Alberto Piasentin, Anna Laura Eusebi, Francesco Fatone

This work reports the long-term operation of the Short-Cut Enhanced Nutrients Abatement (SCENA) for the treatment of anaerobic reject water. SCENA process adopted the via-nitrite pathway for an efficient nitrogen removal combined with the on-site VFAs production through acidogenic fermentation of sewage sludge. The system was operated for more than 450 days, where the applied vNLR was maintained between 0.50 to 0.66 kgN/m3 day, while the average removal efficiency was stable at around 82% (average). Currently, the energy consumption for nitrogen removal (kWh/kgN removed) and related N2O emissions (gN2O-N/kgN removed) are the performance claims target under evaluation to achieve the Environmental Technology Verification (ETV), which will establish the environmental added value of the process through independent assessment.

Session 14
PROTEIN AND VALUE-ADDED RECOVERY: NOVEL TECHNOLOGIES

Room Auditorium

Polymer Grade Succinic Acid Production from Organic Waste: The PERCAL Project Pipeline

Korneel Rabaey

Production processes from side streams such as the organic fraction of municipal solid waste (OFMSW) or stillage generally lead to impure products limiting use for e.g. polymer products. In the Horizon 2020 project PERCAL a pipeline was developed to produce succinic acid in which fermentation was coupled to membrane electrolysis to achieve minimal chemical dosing during production while enabling a pure acidified product stream. The polysaccharide content of OFMSW was enzymatically hydrolysed using a commercial enzymatic cocktail, the resulting aqueous stream contained >70 g/L of C5 and C6 sugars with glucose being the predominant one (over 80%). This hydrolysate was fermented using an engineered Yarrowia lipolytica yeast strain at a yield of 0.26 g/g and a productivity of 0.53 g/L/h. The succinic acid was extracted using membrane electrolysis, at more than 70% coulombic efficiency for succinic acid extraction which increased the production efficiency of the succinic acid, decreased the need for pH control with caustic soda and delivered an acid rich product stream. The resulting stream contained 66.5 g/L succinic acid, it was evaporated to extract volatile organic acids and cooled down to below 4 oC to crystallize out the succinic acid. After subsequent washing, the resulting product was used to produce polyester polyols as precursor for production of polyurethane dispersions. The product achieved a quality comparable to commercially available bio-based succinic acid, showing that it is feasible to produce high quality products from low value substrates. Moreover, preliminary life cycle assessment showed that provided renewable energy is used as driver for the production process, the environmental impact is considerably improved, notably if the productivity of succinic acid production is increased.

Purple Phototrophic Bacteria - Biofilm Technology for Microbial Protein production

Tim Hulsen, Samuel Stegman, Paul Jensen, Damien Batstone

Purple phototrophic bacteria (PPB) can be enriched as concentrated biofilm on submerged, infrared illuminated surfaces, to mediate organics and nutrient removal and recovery as protein-rich biomass. Laboratory and field reactors were designed using either artificial or natural illuminate. The reactors were used to assess biomass production and consistency during separate treatment of piggery effluent, poultry effluent and red meat processing wastewater. In all cases, PPB growth was successful; however, COD conversion and biomass yields were variable. Growth consistency and product quality ultimately determines the applicability of PPB biomass as microbial protein and its value for the manufacturer. This is crucially important for the advancement of PPB mediated technology as photobioreactors are both, capital and operationally expensive and the costs need to be balanced with a high-quality, consistent product to generate a revenue stream.

Economic Potential of Brewery Effluent Treatment with Maximized Heterotrophic Microbial Protein Production

Gustavo Papini Gomes de Sousa, Maarten Muys, Marc Spiller, Francis Meerburg, Siegfried Vlaeminck

Endangered food security demands the formulation of alternative ways for protein production in high quantity, quality and with low footprints. Microbial protein has great potential and dried aerobic heterotrophic bacteria (AHB) biomass is highly attractive as it can be grown on secondary resources. Using high-rate activated sludge as core technology and brewery effluent as substrate, 12 scenarios were tested for AHB production. Obtained data were used to calculate total annual cost and economic indicators to compare with a conventional treatment system. Soybean and fish meal market prices were used to estimate lowest and highest selling prices of AHB biomass. Scenarios with high-rate conventional activated sludge and anaerobic fermentation reached the highest economic output. Net present value and payback period ranged between 4-15M€ and 3.5-10.8 years, respectively. Economic results confirm the potential for AHB protein production on brewery effluents.

Power-to-Protein: Next Step Towards Consumable Single Cell Proteins from Waste Water and Renewable Hydrogen

Frank Oesterholt, Luc Palmen, Willy Verstraete, Jos Boere

In the Power-to-Protein concept lithotrophic hydrogen oxidizing bacteria reassemble carbon dioxide and ammonium-nitrogen from sewage treatment to single cell protein (SCP) while using hydrogen as energy source. The concept was demonstrated at two sewage treatment plants (STPs) in The Netherlands. Parallel to the Power-to-Protein pilot an ammonia recovery pilot was tested for removal efficiency of pathogens while producing ammonia sulphate from reject water of the sludge digestion. Special attention was given to the quality aspects of the SCP that was produced especially with regard to crude protein content, amino acid sequence and in vitro digestibility. A Life Cycle Analysis was performed to compare the production of SCP with traditional protein sources.

Biological Upgrading of Biogas and Production of Single Cell Proteins

Jeanette Madsen, Jacob Kragh Andersen, Nick Ahrensberg, Panagiotis Tsapekos

The Danish utility company BIOFOS is leading a large development project called VARGA introducing several technologies transforming WWTP Avedøre (350.000 PE) into a Water Resource Recovery Facility. A pilot plant has been running for one year and results from anaerobic digestion of biowaste shows methane yields of ~360 Nm3 CH4/ton VS at relatively stable operation. The produced biogas is being biologically upgraded using methanogenic microorganisms to natural gas quality. In a new spin-off project called FUBAF, led by the consultant company EnviDan, the upgraded biogas is converted to Single Cell Proteins. Production of nutrients using a novel Electrochemical System (ES) is a key element in the overall FUBAF concept, which is evaluated in terms of environmental sustainability.

Towards More Sustainable Food Chain: Microbial Protein Production from Catalytically of Biologically Fixed CO2

Myrsini Sakarika, Pieter Candry, Ramon Ganiguè, Korneel Rabaey

The rapidly growing protein demand poses risks to the food sector. At the same time the environmental impact of conventional agriculture is ever-increasing. Microbial protein (MP) has been proposed as a solution to these issues: it is nutrient-efficient, high-quality protein, that can be produced sustainably when considering

wasted resources, such as nitrogen contained in wastewater and CO2, as feedstock. Specifically, CO2 can be converted into formate and/or acetate through physicochemical or biological processes. Such CO2-sourced formate or acetate can circumvent mass transfer limitations caused by the direct use of gaseous CO2. Experiments showed that formate and acetate can be used as carbon sources for growth of several pure and mixed cultures, producing MP. Specifically, we established key kinetic, stoichiometric as well as nutritional parameters, proving the feasibility of this concept. This approach can further decrease the environmental footprint of MP, paving the way for a more sustainable food chain.

Session 15
GOVERNANCE AND REGULATION
Room 6

Barriers and Opportunities for a Circular Economy of Phosphorus in the Baltic Sea Region
Karina Barquet

This paper sheds light on the market and governance barriers and opportunities affecting the development, choice and implementation of innovations for phosphorus (P) reuse in the agriculture and wastewater treatment sectors. Lack of appropriate policy steering and insufficient knowledge on the performance of technologies for reuse are key obstacles for closing the P loop. Structural opportunities presented by the new EU Fertiliser Regulations are likely to improve market opportunities for recovered P. However, the system is currently characterized by a narrow focus on a few innovations for P recovery and reuse which can lead to a new lock-in. Solutions need to address users' acceptability of recovered products while the vision of a circular economy needs to be better articulated in regulations that capture environmental externalities. The paper highlights knowledge gaps, and recommendations for policy and research.

The Politics of a Transition Towards a Circular Economy in the Dutch Wastewater System
Kasper Ampe, Erik Paredis, Lotte Asveld, Patricia Osseweijer, Thomas Block

Recently, environmental and societal problems have increased the calls for a 'transition' or 'paradigm shift' towards resource recovery and the circular economy (CE) in the Dutch wastewater sector. The ERF's (Energy & Resource Factory) translation has considerably narrowed down the interpretation of a transition. This provokes us to ask questions about the political rationales and power struggles that drive the ERF-process: how is a transition interpreted? How and why did the interpretation evolve? And what does this imply for the nature of this so-called transition? These questions were explored by analysing twenty-seven interviews, (participatory) observation and documents through the lens of a power framework that focusses on relational, dispositional and structural power to understand change and stability in transitions.

HOUSEFUL - Innovative Water Energy Material and Nutrient Cycles for the Housing Sector
Maria Wirth, Gaetano Bertino, Johannes Kisser, Roman Grünner

The housing sector is a major contributor to environment and climate challenges in the EU. The lock-in to linear models of resource management are causing adverse impacts throughout a building's life cycle, spanning resource extraction, manufacturing, construction, use and building waste. While the transition towards a circular economy has advanced in industries, this has not yet reached the housing sector. The EU-funded HOUSEFUL project aims to accelerate the transition towards a more circular housing sector, by demonstrating integrated systems of on-site technical solutions for circular management of energy, water, materials and waste in four demo sites in Austria and Spain, covering different socio-cultural contexts and building archetypes. The innovations include water and nutrient recovery from household wastewater by treating the liquid fraction in novel green wall constructed wetlands and processing solids in a household-scale biogas unit and compost cultivator.

Time to Stop Flushing Potable Water with Our Faeces & Urine -- A National Water Strategy Based on Resource Recovery from Re-Engineered Toilets

Jayan Bhagwan, Valerie Naidoo, Sudhir Pillay

Current technical options used in sanitation, primary full flush with reticulated sewerage and on-site sanitation, are limited and cannot be sustainably scaled to meet Sustainable Development Goals (SDGs). New approaches are required that combine the benefits of both approaches, namely, eliminating need for sewers, point-of-use treatment and resource use efficiency and recovery. Under conditions of increasing climatic variability, the norm of flushing potable water with faeces and urine needs to change. Droughts experienced in Cape Town and Eastern Cape of Southern Africa highlighted the illogical approach of potable water flushing. A plethora of re-engineered toilets have been developed nationally and internationally with the aim of recovering up to 30% potable water supply. These re-engineered toilets offer water-saving coupled with organic and nutrient recovery processes to enable commercial possibilities linked to service provision but require policy-enablers to facilitate uptake of RDI.

Impact and Opportunities for the Urban Water Cycle of the 'Fully Circular in 2050' Target of the Netherlands - Circular Water 2050

Kees Roest, Laura Snip, Luc Palmen, Ben Römgens, Andrew Sergrave, Henk-Jan Alphen

The project's aim is to develop a vision and roadmap(s) for the water sector, with a view to the national 'A Circular Economy in the Netherlands by 2050' programme. This involves the raw material efficiency in the urban water cycle, including the extraction and reuse of raw materials. The incoming and outgoing substance flows of the current water chain in the Netherlands have been mapped. The material flows are presented in the form of Sankey diagrams. An overview of possible conceptual and technological innovations that can be relevant for the water cycle in 2050 has been produced. Finally a circular system integration is needed. We investigated, described, discussed, defined and established what is meant in the water cycle with fully circular in 2050.

Decentralised Water and Waste Treatment in View of Resource Recovery

Stijn Van Hulle

The application of decentralised systems offers the benefit that transport of water, energy and nutrients is largely reduced. In order to demonstrate the potential of different techniques that can be used for decentralised treatment several pilot test are being conducted. Efficient water treatment for discharge, potable water production from secondary effluent and nutrient and energy recovery are demonstrated in Flanders and The Netherlands

Session 16
METALS RECOVERY

Room 6

Membrane Electrolysis for Separation of Cobalt from Terephthalic Acid in Industrial Wastewater

Rui Gao, Xochitl Dominguez-Benetton, Jeet Varia, Bernd Mees, Gijs, Du Laing, Korneel, Rabaey

Recovery of valuable metals from wastewaters containing both metals and organics is challenging with current technologies, in part due to their interactions. Typical approaches are chemical intensive. Here, we developed a membrane electrolysis system coupled to an acidic and alkaline crystallizer to enable separate precipitation of the organics and metals without additional chemicals. The target industrial wastewater contained mainly terephthalic acid (TPA), benzoic acid (BA), p-Toluic acid (PA), cobalt (Co), and manganese (Mn). We examined the recovery efficiency of cobalt from two types of synthetic stream and the real process stream using several configurations. The alkaline crystallizer achieved a cobalt recovery efficiency of 94.51 ± 0.21 % (pH 11.37 ± 0.21) in batch tests of the simple synthetic stream (TPA and Co). Then, the system was operated continuously with complex synthetic stream (TPA, BA, PA, Co and Mn). The alkaline crystallizer achieved a cobalt recovery efficiency of 97.78 ± 0.02% at pH 11.68 ± 0.02. A real stream was tested over 5 h runs in batch showing 82.92 ± 0.22 % cobalt recovery at pH 8.07 ± 0.02.

Detection Removal and Recovery of Metals from Water Sludge and Fly Ash

Kees Roest, Edwin Buijzer, Luc Palmen, Julian Muńoz Sierra

The focus of water treatment is increasingly shifting to the recovery of raw materials, partly stimulated by the quest for a circular economy. Drinking water companies, Water Authorities and sludge final-processors are particularly concerned with the recovery and useful reuse of residuals. Besides water, phosphorus and cellulose there are also opportunities for the recovery of (rare) heavy metals and earth metals, including copper, zinc, cobalt, silver, gold and palladium. Apart from the benefits of recovering metal/metals, the removal of metals improves effluent quality, sludge quality and residual ash, and therefore opens alternative disposal possibilities.

Towards Lithium Selective Membranes: Crownether Containing Poly-Electrolyte Multilayer Membranes

Mohammad Kazemabad, Arne Verliefde, Emile R. Cornelissen, Arnout D'Haese

The growing need of industries in lithium can be answered with alternative sources. However, most of these sources contain high amounts of chemically and physically similar Na, K and Mg. Achieving monovalent cation selectivity in membranes can have a major impact in introducing them to lithium mining industry. In this study, we have embedded 15-crown-5 ether, a cation selective moiety in the Polyethylenimine (PEI) chain, which was used to prepare polyelectrolyte multilayer membranes. The resulting membranes were characterized in terms of stability, thickness and water and solute permeability. It was shown that manufactured membranes showed Li/K selectivity for a period of 90 minutes, and increased salt rejection properties. Moreover, stability of the membranes at high salinities was evaluated.

An Integrated Approach for HCl and Metals Recovery from Waste Pickling Solutions: Pilot Plant Design and Operations

Rosa Gueccia, Daniel Winter, Serena Randazzo, Andrea Cipollina, Giorgio Domenico Micale, Joachim Koschikowski, Florian Gross

Continuous regeneration of industrial pickling solutions and recovery of valuable materials are implemented in a pilot-scale plant including diffusion dialysis, membrane distillation and reactive precipitation units. The main results of the preliminary assessment of on site operation are presented. Different hydrochloric acid concentration and metals composition were investigated and the performance of the system were analysed in terms of quality of recovered compounds, energy efficiency and environmental footprint.

Session 17
MICROALGAE-BASED PROCESSES

Room Theatre

Application of Microalgae for Wastewater Treatment and Recovery of Bioenergy and High-value Bioproducts

Larissa Arashiro, Ivet Ferrer, Diederik P.L. Rousseau, Stijn W.H.Van Hulle, Marianna Garfi

Resources recovery from wastewater has been addressed as a key element towards a circular economy within the water cycle. Microalgae-based systems are widely used for algal biomass growth but also as efficient systems for nutrient and energy recovery when combined with wastewater treatment. This research assessed the performance of a high rate algal pond (HRAP) and photobioreactors (PBRs) in terms of wastewater treatment efficiency and the potential to recover energy through biogas and to extract pigments from the biomass. Results indicated that efficient wastewater treatment was achieved (removing up to 92% of NH4+-N and 55% of COD). The production of biogas from the biomass grown in the HRAP (207-258 mL CH4/g VS), as well as the extraction of phycocyanin (PC) and phycoerythrin (PE) from the cyanobacterial biomass grown in the PBRs (up to 14.1 mg PC/g DW and 6.36 mg PE/g DW) were successfully achieved.

Recovery and Recycling of nutrients from wastewater with algae

Maja Berden Zrimec, Ana Cerar, Borut Lazar, Matej Slapnik, Lara Resman, Rok Mihelič, Robert Reinhardt

Algal pond systems (APS) are being tested at the demo sites in Slovenia and Spain to evaluate and optimise the resource recovery from wastewaters by algae and the subsequent valorisation of algal biomass as a secondary raw material for various products, namely material fillers, biogas substrate, agricultural biostimulants and fertilisers. When APS was used to treat the digestate from a thermophilic biogas plant, the maximum volume treated daily in 100 m2 main pond was 500 L, with an average 90% COD reduction (COD in digestate was in the range 6000 – 10.000 mg/L), 91% N removal, 64% P removal and biomass production of up to 30g/m2day-1 in the summer months. For biogas production, a pre-treatment of biomass is needed to increase the biogas production, most efficient method being a thermal pre-treatment. Thermal pre-treatment proved to be most efficient also for the biostimulative effects on crops in the preliminary testing.

Integration of Microalgae Culturing as a Side-stream Process into Wastewater Treatment Plants: An LCA Evaluation

Lucia Rigamonti, Camilla Tua, Elena Ficara

The IMAP Project aims to investigate the integration of a microalgae culturing within an existing wastewater treatment plant in the surroundings of Milan. In this facility, microalgal open ponds have been designed to be fed with the supernatant from the digestate dewatering, rich in nutrients, and with the CO2 from the flue gas from the combined heat and power unit. The produced algal biomass is sent to the anaerobic digesters for an extra-production of biogas. This paper deals with the Life Cycle Assessment analysis of the system, carried out to evaluate possible environmental improvements in the wastewater treatment due to the new algal unit.

Use of Microalgae Grown on Fish Tank Residual Nutrients as Feed for Copepods to Enable Circular Bio-economy in Aquaculture

Borja Valverde Pérez, Lars A Ahrens, Anette M. Christensen, Carlos O. Letelier-Gordo

This study focuses on the development of a new value chain in aquaculture, whereby nutrients from fish tank effluents are first encapsulated in algal biomass. Algal biomass will be fed to copepods, which are a good feed for fish larvae. The study offers a cost-effective algal biomass utilization compared to traditional approaches which require resource intensive processes for harvesting.

Session 18
HIGH VALUE CHEMICALS/MATERIALS RECOVERY

Room Auditorium

Photoelectrocatalytic Production of Hydrogen and Commodity Chemicals from Desalination Brine

William Tarpeh, Linchao Mu

Desalination is a promising approach to convert seawater and brackish water into potable fresh water; however, widespread implementation is limited by high process inputs (e.g., energy, cost) and inadequate brine management. Recovering value-added products such as energy and commodity chemicals from concentrated brine could potentially address both challenges. In the proposed research, we apply photoelectrochemical water splitting and salt splitting to generate hydrogen fuel (H2), sodium hydroxide (NaOH), and hydrochloric acid (HCl) from desalination brine. Particularly in a world facing water scarcity, potable water is not an ideal influent for water splitting. Salt splitting is used to generate acids and bases from various salts; using sodium chloride requires controlling chloride oxidation. With this approach, we reimagine "waste" brine as a source of valuable products: fuel, acids, and bases.

Production of N-caproate from Food Waste Without pH Control: Consecutive Lactate Formation and Chain Elongation

Carlos Contreras Davila, Cees Buisman, David Strik

Biological chain elongation allows the recovery of carbon and value from waste streams by the production of medium-chain fatty acids (MCFA). Nevertheless, this technology usually relies on the addition of external electron donors to drive the process. Here, we steer food waste fermentation to lactate formation which is further used as electron donor for MCFA production, mainly n-caproate. Lactate was determined to be a main electron donor for n-caproate production. n-caproate was the second main metabolite produced (3.4 g/L) and n-caproate carbon specificities increased from 9 to 22% during the experiments.

A Potential P Fertilizer – Biochar Produced by EBPR Sludge

Tingting Qian, Yan Zhou

To evaluate the potential of EBPR sludge biochar (ES biochar) to be a phosphorus (P) fertilizer, the release behavior and bioavailability of the P in two ES biochars (i.e., E400/E700 produced at 400/700 oC) were investigated. The results show that ES biochar contained a considerable portion of fast-release P, and the readily soluble P of the ES biochar included ortho-P, pyro-P, and poly-P. E700 could facilitate the absorption of P by Pseudomonas. putida (P. putida), which could be due to that low concentration of ortho-P in the medium could stimulate the absorption of P by P. putida. As some free radicals and hazardous organic matters could be released from E400 when P. putida was cultivated with E400, E400 inhibited the formation of poly-P in P. putida. The results of this study indicate that E700 could be a superior P fertilizer than E400.

Advanced Composting and Bio-drying as an Opportunity to Recover Material and Energetic Resources from Sludges

Nagore Guerra, Mabel Mora, Lara Pelaz, Jonatan Ovejero, Laia Llenas, Belèn Puyuelo, Joan Colón, Sergio Ponsá

The need to change the current paradigm from linear economy to circular economy makes the recovery of resources from waste effluents one of the current and future technological priorities. In this context, sewage sludge represents a great challenge and at the same time a great opportunity for the recovery of resources, both material, and energy. Within the framework of the H2020 SMART Plant project, BETA Tech. Centre is developing two technologies to maximise resource recovery from different types of sludge. Firstly, phosphorus-rich biofertilisers are being produced through advanced dynamic composting processes treating sludge from EBPR and SCENA processes. Secondly, cellulose-rich sludge is being treated through biodrying processes to produce biomass fuel with a calorific value similar to that of pine chips.

POSTER PRESENTATIONS

CODE	TITLE	AUTHOR(S)
P001	**Nitrogen Recovery from Blackwater Using Bioelectrochemical Systems**	*Marti Aliaguilla, Eduard Borrás, Daniele Molognoni, Pau Bosch-Jimenez, Maria del Pilar Bernícola, Júlia García-Montaño, Sonia Sanchis*
P002	**Can We Benefit from Hydroxylamine and Hydrazine Generating in Anammox Reactors?: The Possible Use in Nanobiotechnology Applications**	*Bilge Alpaslan Kocamemi, Esra Erdim*
P003	**Wastewater Reuse for Agricultural Purposes: A Case Study**	*Eleonora Aneggi, Alessandro Moretti, Daniele Goi*
P004	**Evaluating the Potential Production of Bio-based Products from Waste Streams**	*Merve Atasoy, Zeynep Cetecioglu Gurol*
P005	**Avoiding Eutrophication in Small Water Bodies: An Hydrogenotrophic Approach**	*Raquel Barbosa, Tom Sleutels, Nico Bonn, Willy Verstraete*
P006	**Pilot-scale Treatment of Combined Sewage Overflows (CSOs) and Its Further Possible Agricultural**	*Alice Botturi, Saba Daneshgar, Francesco Fatone, Anna Laura Eusebi*
P007	**Enhancement of Sludge Solubilisation by Carbon Nanotube-coated Vessel Applied Microwave Irradiation**	*Kyeong Hwan Kang, Jenghyeon Kim, Hyeonjin Jeon, Imgyu Byun*
P008	**Enhancement of the Direct Lipid Extraction Yield From Wet Algae by Optimization of the Microwave Irradiation Conditions**	*Hyeonjin Jeon, Junghyeon Kim, Kyeong Hwan Kang, Imgyu Byun*
P009	**Enhancement of the Microwave Energy Efficiency by the Adaption of a Reflective-wave Circulating Unit**	*Junghyeon Kim, Hyeonjin Jeon, Kyeong Hwan Kang, Imgyu Byun*
P010	**Anaerobic Digestion of Leather Pickling Wastewater and Leachate Mixture: Effect of Salinity on Reactor Performance**	*Monica Carvalheria, Bruno Oliveria, A. Maria Sampaio, Joana Cassidy, Catarina S.S. Oliveria, Maria A.M. Reis*
P011	**Selecting a Photo-Enhanced Biological Phosphorous Removal System Starting from Conventional Wastewater Treatment Plant Sludge**	*Virgina Carvalho, Elisabete Freitas, Joana Fradinho, Adrian Oehmen, Maria Reis*
P012	**Impact of Elevated CO2 Partial Pressure on the Thermodynamics and Kinetics of Syntrophic Propionate Oxidation**	*Pamela Ceron, Ralph Lindeboom, Korneel Rabaey, Jules van Lier*
P013	**Phosphorus Recovery from Excess Sludge through Alkaline Fermentation: Studies for Pilot-scale Design**	*Sevil Coşgun, Büşra Kunt, Neslihan Semerci*
P014	**Aerobic Capture of Organic Carbon for Anoxic Nitrogen Removal via Intracellular PHA Storage in a Novel Two-stage SBR Process Treating Sewage**	*YouWei Cui, Chang Lin Jin*
P015	**Pilot-Scale Study of Phosphate Precipitation Process from Synthetic Aerobic Sludge**	*Saba Daneshgar, Armando Buttafava, Arianna Callegari, Andrea G. Capodaglio*
P016	**Phosphorus Recovery on Apatite Filters: Developing a Mechanistic Model**	*Laura Delgado, Denise Blanc, Mathieu Gautier, Stéphane Troesch, Pascal Molle*
P017	**Design And Optimisation of Integrative Process Systems for Resource Recovery From Wastewater**	*Alex Durkin, Miao Guo*
P018	**Phosphate Recovery from Wastewater Using Porous Calcium Silicate Hydrate Derived from Carbide Slag**	*Dexin Fang, Zhuyao Fang, Fangying Ji*
P019	**Phosphorus Removal by a Sequence Batch Moving Bed Biofilm Process**	*Abaynesh B. Fanta, Sveinung Sægrov, Stein V. Østerhus*

P020	**Solar Drying as a Nature-based Approach for Nutrients Recovery from Digested Animal Manures**	*Lluis Morey, Victor Riau, Laura Tey, Carme Biel, Angel Porta, Joan Soler, Belén Fernández*
P021	**The Role of Fermentative Hydrogen as Electron Donor in Bioelectrochemical Systems for Nutrient Recovery**	*Steffen Georg, Inigo de Eguren Cordoba, Tom Sleutels, Philipp Kuntke, Annemiek ter Heijne, Cees J. N. Buisman*
P022	**Tools for the Selective Production of Purple Bacteria in Raceway Reactors as Source of Microbial Protein**	*Abbas Alloul, Damian Adamczyk, Siegfried Vlaeminck*
P023	**The Effect of Free Nitrous Acid and Free Ammonia Sludge Pre-treatment on Energy Recovery from High Rate Activated Sludge and Partial Nitritation Process**	*Angelica GuePero Calderon, Haoran Duan, Min Zheng, Shihu Hu, Zhiguo Yuan*
P024	**(Bio-)electrochemical Technologies for Resource Recovery In Wastewater Treatment Wetland Systems**	*Marco Hartl, Marianna Garfi, Jaume Puigagut, Diederik Rousseau, Gijs Du Laing*
P025	**Low Phosphorus Effluent Concentrations at the Wastewater Treatment Plants Using Nanoparticle Modified Materials**	*Marek Holba, Lenka Hoferková*
P026	**Short Branch Chain Fatty Acid Production from Methanol by an Open Culture Enrichment**	*Shengle Huang, Ramon Ganigué, Robbert Kleerebezem, Korneel Rabaey*
P027	**Iron-reducing Biocathode for Phosphorus Remobilization from FeP Complexes Contained in Wastewater Sludge**	*Dongya Sun, Xi Chen, Xiaoyuan Zhang, Peng Liang, Xia Huang*
P028	**Enhanced Nitrogen Removal Using Corncob as Carbon Source and Biofilm Carrier: Performance and Microbial Shift**	*Liping Huang, Jiangyu Ye, Hongwei Xiang, Jianhua Jiang*
P029	**Diffusion Gradients in Thin Films as a Potential Monitoring Tool to Assess Trace Metal Bioavailability in Anaerobic Digestion**	*Aleksandra Ilic, Gjis Du Laing, Jan Bartacek*
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