Treatment of pollution in constructed wetlands: from the fundamental mechanisms to the full-scale applications

Florent Chazarenc¹ • Vincent Gagnon¹ • Elif Asuman Korkusuz²

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Introduction

The “International Symposium on Wetland Pollutant Dynamics and Control” (WETPOL) has become a reference for fundamental and practical knowledge on pollutant transformation inside natural and constructed wetlands (CWs). Every 2 years, leading wetland experts meet and present their latest research activities and experiences. The first WETPOL symposium was held in Gent (Belgium) in 2005, followed by Tartu (Estonia) in 2007, Barcelona (Spain) in 2009 and Prague (Czech Republic) in 2011.

The 5th WETPOL symposium was held from October 13 to 17, 2013, at “La Cité” events center in the heart of the historical city of Nantes, France. The symposium was organised under the leadership of the École des Mines de Nantes and the GEPEA laboratory (Process Engineering for Environment and Food), which is specialised in environmental engineering for air and water treatment.

Presentation of WETPOL 2015

The 5th WETPOL symposium welcomed more than 250 participants from institutions including universities, research institutes and small- and medium-sized enterprises coming from 47 different countries. The latest finding on removal of pollutions in natural and CWs was presented, with a total of 130 oral and 40 posters.

At this symposium, five keynote speakers were invited:

- Bill Mitsch, USA, “Protecting the Florida Everglades wetlands with wetlands—can stormwater phosphorus be reduced to oligotrophic conditions?”
- Jacques Brisson, Canada, “Ecosystem services of wetlands: does plant diversity really matter?”
- Lars Duester, Germany, “Wastewater, examples on new organic contaminants, upcoming metal(loid)s, nanomaterials & the transfer/transformation in wetlands”
- Joan Garcia, Spain, “The cartridge theory: a conceptual approach to horizontal-flow wetlands’ functioning”
- Kela Weber, Canada, “The role and characterization of microbial communities in wetlands for water pollution control”.

Moreover, there were three interactive discussion sessions with invited speakers, where Dirk Esser, France; Sylvie De Blois, Canada; and Chris Tanner, New Zealand, presented and chaired the discussions on “30 years of CWs research in France”, “global change and wetlands” and “wetlands to control diffuse pollution at catchment scale”, respectively.

Clara Corbella and Jaume Puigagut were awarded as “The best young professional” for their poster entitled “Preliminary results on methane emission from horizontal subsurface flow treatment”.

Responsible editor: Philippe Garrigues

✉ Vincent Gagnon
vincent.gagnon@mines-nantes.fr

Florent Chazarenc
florent.chazarenc@mines-nantes.fr; <http://www.mines-nantes.fr/WETPOL>

Elif Asuman Korkusuz
asuman@optimet.com.tr; <http://www.optimet.com.tr>

¹ Department of Energy Systems and Environment, École des Mines de Nantes, 4, rue A. Kastler, BP 20722 44307 Nantes Cedex 3, France

² OptiMet Engineering Environmental Technologies Industry Trade Co., Ltd., Ankara, Turkey

Besides the oral and poster sessions, two conference tours have been organised, where the participants have visited:

- (i) The famous salt marshes of Guérande in the northern region of Nantes along with the visit of the constructed wetlands of “Bouvron”, which was designed to treat 1900 population equivalents (Pe), where the raw domestic wastewater is treated in a three-staged vertical flow CW with an area of 6500 m². The final treated effluent is used to irrigate 4 ha of willows.
- (ii) The beautiful natural lake of Grand-Lieu, fed by the Ognon and Boulogne rivers in the southern region of Nantes and the vertical flow CW of “La Chapelle Rousselin”, which was built in 2010. This CW was implemented to improve phosphorous removal, with a third-stage filter filled with Déphorite®, an industrial by-product of the steel industry (EAF). Monitoring results showed a TP reduction of more than 60 % after 3 years of operation.

Content of this special issue

In CWs, pollutants are treated by a combination of physical, chemical and biological processes (Fig. 1). The removal of each category of pollutant is typically associated with a specific microbial functional group. Therefore, there have been several studies aiming at testing specific CWs design and operational methodologies to enhance those microbial functional groups and optimise treatment performance. Early publications typically

assumed the influence of microbial processes in CWs, based primarily on inference from known processes in other wastewater treatment systems and/or natural wetlands. Many research have shown circumstantial evidence (black box approach) to corroborate these basic assumptions based primarily on measurement of changes in water chemistry, especially for the treatment of organic matter, nitrogen or xenobiotic compounds (e.g. phenols) in domestic wastewater.

This special issue consists of ten selected papers presented at the 5th WETPOL 2013 symposium. The main theme of this special issue will focus on the treatment of pollution by constructed wetlands, covering the fundamental mechanisms to the full-scale applications. The aim is to cover the most recent discoveries in the field, such as microbiology, modelling and metal/nutrient removal.

The specific topics related to fundamental mechanisms of this special issue will concentrate on the following:

1. Physical processes in constructed wetlands, with a focus on the impact of different design and operational variables on TSS removal and on the clogging phenomena to treat urban wastewater (Al-Isawi et al. 2015)
2. Combined biological and chemical processes in CWs for the treatment of
 - (a) landfill leachate in polyculture CWs (Madera-Parra et al. 2015)
 - (b) surfactant-polluted water using cascade CWs (Tamiasso et al. 2015)
3. Microbiological processes with an emphasis on nitrogen cycle to

Fig. 1 Main removal mechanisms in CWs (adapted from Reddy and D'Angelo 1994, illustrated by V. Gagnon)

- (a) compare different CW configurations on NH_4 removal from contaminated groundwater (Coban et al. 2015)
- (b) assess the impact of nitrogen removal rates by analysing performances of several multistage CWs, combining oxidised and anoxic conditions (Gajewska et al. 2015)
- (c) model partial nitrification and denitrification in a hybrid biofilm reactor (Zeng et al. 2015).

The specific topic related to the full-scale application in this special issue will concentrate on the following:

1. The use of CWs to treat variable flow wastewater including for
 - (a) the use of hybrid CWs to treat dairy milking parlour effluent (Harada et al. 2015)
 - (b) the use of intensified wetland system to treat swimming pool effluent (Van Oirschot et al. 2015)
2. The status on the use of CWs and nature based on domestic wastewater treatment in Central and Eastern Europe (Istenic et al. 2015)
3. The use of CWs to treat sludge from urban wastewater treatment plants (Nielsen and Bruun 2015).

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We regret to inform you that one of the co-authors of a paper in this special issue, Dr. Peter Kuschik, from the Helmholtz Centre for Environmental Research (UFZ), Leipzig (Germany), passed away unexpectedly on October 14, 2014.

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Florent Chazarenc is a Ph.D. in environmental engineering. He is an associated professor at École des Mines de Nantes in France at the Department of Energy Systems and Environment (since 2007), and he is Adjunct Professor at École Polytechnique Montréal Quebec in Canada (since 2012). His research expertise is in wastewater treatment with an emphasis on the use of extensive process like constructed wetlands. Over the last 8 years, he conducted researches on the use of intensifications to upgrade P and N removal and on the understanding of fundamental mechanisms involved in pollutants removal in constructed wetlands. He published more than 40 papers in peer review journals. He was the Chair of the 5th International Conference on Wetland Pollutants Dynamics and Control (Nantes 2013).

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Dr. Vincent Gagnon received a bachelor's degree in biological sciences (2004) from the University of Montreal, with a specialisation in biology and biotechnology. He did his master (2007) and doctorate (2012) at the "Institut de Recherche en Biologie Végétale" and earned both degrees in biological sciences from the University of Montreal. His Ph.D. was entitled "Effect of plant species in treatment wetlands according to season, type of filter and nature of pollutants". He is currently a post-doctoral researcher in the Department of Energy Systems and Environment at École des Mines de Nantes, France. His main research interest is on the influence of plants on microbial ecosystem responsible for the treatment of pollutants in constructed wetlands. He is also involved in projects using constructed wetlands to treat: landfill leachate in Africa, eutrophic lake in China, industrial wastewater at the Reunion Island and domestic and agro-food wastewater in France. He was a member of the

post-doctoral researcher in the Department of Energy Systems and Environment at École des Mines de Nantes, France. His main research interest is on the influence of plants on microbial ecosystem responsible for the treatment of pollutants in constructed wetlands. He is also involved in projects using constructed wetlands to treat: landfill leachate in Africa, eutrophic lake in China, industrial wastewater at the Reunion Island and domestic and agro-food wastewater in France. He was a member of the

scientific and the organising committee of the 5th WETPOL symposium and a co-editor of the conference proceedings.

Dr. Elif Asuman Korkusuz graduated in 1996 from the Department of Environmental Engineering of the Middle East Technical University (METU), Ankara, Turkey, with a degree of B.Sc. and in 1998 with a degree of M.Sc., respectively. As she has developed a passion for the constructed wetlands (CWs), she has prepared a M.Sc. thesis with the title of “Feasibility of a controlled wetland in the Mogan-Eymir system”. Dr. Korkusuz has conducted her Ph.D. studies in the

Department of Biotechnology, METU (1999–2004), as a project assistant. During her Ph.D. studies, she has applied pilot-scale CWs on the campus of METU and has monitored the treatment efficiencies of those

CWs. This study was one of the leading CW studies in Turkey (“Domestic wastewater treatment in pilot-scale constructed wetlands implemented in the METU”).

In her first post-doc studies at the Technical University of Crete, Greece, she has prepared a “Manual of practice on CWs for wastewater treatment and reuse in Mediterranean countries” (Project No: MED-REUNET II-INCO-CT-2003-502453). Afterwards, between 2005 and 2007, she has worked as an EU FP6 Marie Curie Intra European Fellow (IEF) post-doc scholar at the University of Natural Resources and Applied Life Sciences, Department of Water-Atmosphere-Environment, Institute of Sanitary Engineering and Water Pollution Control, Vienna, Austria (“Optimization of Nutrient Removal in Constructed Wetlands Using Special Substrates and Numerical Simulation” (ONUREM)) (Project No: 515515).

After she has returned back to Ankara in 2007, she has started to work as a freelance consultant for several national and international environmental projects in Turkey. Since 2011, she is the owner of the OptiMet Engineering-Environmental Technologies Industry Trade Co., Ltd., in Ankara, Turkey.