

World Environmental and Water Resources Congress 2019

Water, Wastewater, and
Stormwater; Urban Water
Resources; and Municipal
Water Infrastructure


Selected Papers from the
Proceedings of the
World Environmental and
Water Resources Congress 2019

Pittsburgh, Pennsylvania
May 19–23, 2019

ASCE

Edited by
Gregory F. Scott, P.E.

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WORLD ENVIRONMENTAL AND WATER RESOURCES CONGRESS 2019

*WATER, WASTEWATER, AND STORMWATER; URBAN
WATER RESOURCES; AND MUNICIPAL WATER
INFRASTRUCTURE*

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SPONSORED BY
Environmental and Water Resources Institute
of the American Society of Civil Engineers

EDITED BY
Gregory F. Scott, P.E.
William Hamilton, Ph.D., P.E.



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Preface

We are excited to offer the proceedings of the 2019 World Environmental and Water Resources Congress. The proceedings include published papers from an engaging and challenging array of technical sessions, posters, and workshops at the Environmental and Water Resources Institute's (EWRI) 19th Annual Congress, held in Pittsburgh, Pennsylvania, May 19-23, 2019. This conference is a leading venue for professional interaction among engineers and scientists, covering disciplines related to water and environmental resources and infrastructure.

America's infrastructure is in urgent need of attention. The 2017 American Society of Civil Engineers' Report Card for America's Infrastructure estimates that an investment of over \$4.5 trillion is needed to return the nation's infrastructure to a state of good repair. Of critical importance to the public's health and safety are the needs of water focused infrastructure. The Environmental Protection Agency (EPA) estimates that wastewater and stormwater collection and treatment needs are \$271 billion as of January 2012 and drinking water utilities needs are \$472.6 billion as of March 2018. While significant, the needs are not limited to the United States alone. According to the World Health Organization (WHO), contaminated drinking water is estimated to cause 502,000 diarrheal deaths each year, and by 2025, half of the world's population will be living in water-stressed areas. Compounding the state of water infrastructure are on-going changes to the climate. Scientific evidence unequivocally indicates these changes are accelerating. While debate remains as to the causes and how best to slow, stop and/or reverse these changes, it falls to professionals in the water fields to address the challenges to rebuilding the world's water infrastructure to be more resilient and reducing direct impacts such as flooding and indirect impacts such as disruption of critical economical services.

The 2019 EWRI Congress covers a wide range of topics that attempt to provide innovative and sustainable solutions to ensure that our water and environmental infrastructure and resources will be improved and built to secure and protect them for the future. We proudly host the Congress under the auspices of the American Society of Civil Engineers (ASCE).

Within the six (6) volumes of the proceedings, more than 150 written scientific and technical papers from nearly 800 oral and poster presentations focusing on the subject areas of various EWRI Councils are included. A list of subject area tracks is included in the acknowledgements below. We hope these proceedings serve to enhance your knowledge and encourage you to follow up with more detailed publications by the same authors, and related papers, typically found in ASCE technical journals.

This collection contains papers organized by the following EWRI Councils:

- **Water, Wastewater and Stormwater Council** whose purpose is to create, organize and manage the activities of various technical committees dealing with the engineered infrastructure and its effect on the environment, particularly water resources. Attention will be focused on assessing the effects and the important interrelationships of water resources, facilities and installations and necessary environmental and public health protection measures/systems needed for the functioning and sustainability of an adequate infrastructure.
- **Symposium: Stormwater Urban Water Resources Council** whose purpose is to advance engineering knowledge and practice through stimulating and guiding research and assisting the financing thereof in the field of urban hydrology; to organize research projects; in cooperation with professional committees, to interpret the findings of research; and to make available information and recommendations resulting from such research. The content fosters the development of improved or advanced urban watershed management and best management practices.
- **Municipal Water Infrastructure Council** whose purpose is to work with professionals in the public and private sectors directly involved in urban water infrastructure. This committee provides a community for practical professional practice individuals to develop products with an emphasis on owner/operator perspectives.

Acknowledgments

Preparation and planning for this Congress strongly depends on the dedication of those individuals who plan session topics, solicit abstracts and papers, oversee reviews of all submissions. We are deeply grateful to all who have provided this considerable effort, especially the track chairs listed below:

17th Groundwater Symposium	Paul Mathisen & Amy Chan-Hilton
Emerging & Innovative Technologies	Barak Fishbain
Environmental	Wendy Cohen & Lisa Hayes
History & Heritage	Larry Magura & Jerry Rogers
Hydraulics & Waterways	Fabian Bombardelli
Hydro-climate/Climate Change Symposium	Levent Kavvas
International Issues	Erfan Goharian & Ali Mirchi
Irrigation & Drainage	Stuart Styles
Planning and Management	Mashor Housh & Debora Piemnonti
Standards	Dr. Kathlie S. Jeng-Bulloch
Stormwater Symposium	Bill Hunt & Sarah Waickowski
Student Competition	Wes Lauer
Sustainability	Joshua Peschel
Watershed	Levent Kavvas & Don Frevert
WDSA	Terra Haxton
New Professionals	Erfaneh Sharifi
Desalination Symposium	Luzma Nava
Water, Wastewater and Stormwater	Bridget Wadzuk & Arnie Strasser
Professional Practice	Kristin White
Education	Angelica Huerta

We also acknowledge the members of the Congress Organizing Committee, without whose time and efforts the event would not be possible.

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Finally, we acknowledge and thank EWRI staff who, in the end, makes this conference a reality.

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Contents

Stormwater Symposium

Heat Transfer Analysis of Recycled versus Conventional Green Roof Media	1
Rashid Kaveh and Shirley E. Clark	
Performance Analysis of Rainwater Tanks at California State University Long Beach.....	7
Rebeka Sultana and Marvie Baconawa	
Bone Char as a Potential Sorbent for Metal Removal from Urban Runoff: Effect of Temperature on Sorption	14
Timothy M. Dittrich, Rachel Hakim, Mohammed Dardona, Shariat Mobasser, Anastasia Alexandrova, and Chandra M. Tummala	
Curb Inlet Efficiency Evaluation under Constant Rainfall and Upstream Inflow	20
Xiaoning Li, Xing Fang, Jianlong Wang, Gang Chen, and Junqi Li	
Effects of Deicing Salts on Soil Infiltration Rate and Pollutant Uptake	34
Karan R. Jain, Sai P. Kakuturu, and Shirley E. Clark	
Exploring the Potential for Simulating System-Level Controlled Smart Stormwater System	46
Jiada Li, Steven Burian, and Carlos Oroza	
Assessing the Performance of Bioretention and Sand Filter Media Using Columns and Synthetic Stormwater.....	57
Abtin Shahrokh Hamedani, Arianne Bazilio, Crista Cerda, Alexander Manjarres, Alani Hall, Heather Shipley, and Marcio Giacomoni	
Variation in Nutrient and Metal Retention in Bioretention Systems with Mycorrhizae-Inoculated Soil	71
Cara Poor and Jenna Kube	
ICSM: A New Stormwater Management Strategy to Support the Urban Growth of Developing Countries in Asia	80
Faisal Ahammed, Guna Hewa Alankarage, John R. Argue, and Christina W. Tsai	
Urban Runoff and Pollutant Reduction by Retrofitting Green Infrastructure in Storm Water Management System.....	93
Sailuj Shakya, Kazi Ali Tamaddun, Haroon Stephen, and Sajjad Ahmad	
South Side Settlement Heritage Park Creating Sustainable Neighborhood Wet Weather Solutions in Columbus, OH	105
Jason T. Sanson and Eric D. Onderak	

TOPKAPI Model and Its Application of Flood Early Warning and Forecasting in China	113
Lili Liang, Kuang Li, Yuntao Ye, Haiqing Xu, and Yufeng Hu	

Evaluating the Effectiveness of Bioswales and Catch Basin Inserts for Treating Urban Stormwater Runoff in Detroit, Michigan	124
Chandra Mouli Tummala and Timothy M. Dittrich	

University Park Neighborhood Rain Gardens Project in Los Angeles, California	132
K. Majid Sadeghi, Wing Tam, Shahram Kharaghani, and Hugo Loáiciga	

Effect of Spatial Allocation of Green Infrastructure on Surface-Subsurface Hydrology in Shallow Groundwater Environment.....	147
Kun Zhang and Ting Fong May Chui	

Water, Wastewater, and Stormwater

A New Type of Aerator for Landscape Water System and Comparative Analysis.....	153
Zhan Wang, Shuo Wang, and Dachun Zhang	

An Investigation of Monochloramine Recoveries under Different Mixing Condition	160
Farhikhteh Samadi, Andrew Kruzic, and Srinivas Prabakar	

Characterization of Polycyclic Aromatic Hydrocarbons and Engineered Nanomaterial in Surface Water Environment	173
Jejal Bathi, Shirley E. Clark, Syed Tareq, Shuvashish Roy, and Venkata R. Gadhamshetty	

Green Stormwater Infrastructure for CSO Control	184
Bernadette M. Callahan	

Fruit Peels as Natural Adsorbents to Remove Chromium (Cr⁶⁺) from Synthetic Textile Wastewater.....	190
Rizki Ibtida Prasetyaningtyas, Saskia Anindya Putri, Faegheh Moazeni, and Shirley Clark	

Environmental Impacts of Concentrate Management Alternatives: Criteria for Comparative Assessment	201
Berrin Tansel	

Novel Technologies for Concentrate Management	206
Berrin Tansel	

Treated and Regulated Effluents of the U.S. Municipal Wastewater to Making Direct Potable Reuse (DPR).....	211
S. Rao Chitikela, Venkata Gullapalli, and William F. Ritter	

Phosphorus Removal from Wastewater 222
Alexander M. Roper and Shannon L. Isovitsch Parks