Scientific and Technical Report No. 27

Wetland Technology

Practical Information on the Design and Application of Treatment Wetlands

Edited by Günter Langergraber, Gabriela Dotro, Jaime Nivala, Anacleto Rizzo and Otto R. Stein

Wetland Technology

Practical Information on the Design and Application of Treatment Wetlands

Scientific and Technical Report Series No. 27

Wetland Technology

Practical Information on the Design and Application of Treatment Wetlands

---

Edited by

Günter Langergraber, Gabriela Dotro, Jaime Nivala, Anacleto Rizzo and Otto R. Stein

IWA PUBLISHING

Published by **IWA Publishing**
Alliance House
12 Caxton Street
London SW1H 0QS, UK
Telephone: +44 (0)20 7654 5500
Fax: +44 (0)20 7654 5555
Email: publications@iwap.co.uk
Web: www.iwapublishing.com

First published 2019

British Library Cataloguing in Publication Data
A CIP catalogue record for this book is available from the British Library

ISBN: 9781789060164 (Paperback)
ISBN: 9781789060171 (eBook)
ISBN: 9781789060188 (ePub)

This eBook was made Open Access in January 2020.

Contents

Editors and Authors

Editors

Name	Affiliation
Langergraber, Günter	BOKU University Vienna, Austria
Dotro, Gabriela	Cranfield University, United Kingdom
Nivala, Jaime	Helmholtz Center for Environmental Research (UFZ), Germany
Rizzo, Anacleto	Iridra S.r.l., Florence, Italy
Stein, Otto	Montana State University, USA

Authors

Name	Affiliation	Section Numbers
Anconelli, Stefano	Consorzio di Bonifica Canale Emiliano Romagnolo, Bologna, Italy	6.3
Arias, Carlos	Aarhus University, Denmark	5.10, 5.11,
Austin, David	Jacobs, USA	5.8
Breuer, Roman	Bauer Nimr LLC, Muscat, Oman	6.5
Bruns, Stefan	Polyplan GmbH, Bremen, Germany	4.15
Bresciani, Riccardo	Iridra S.r.l., Florence, Italy	5.2, 6.6, 6.7, 6.8
Cirelli, Giuseppe Luigi	University of Catania, Italy	4.7, 5.4
Devanadera, Ma. Catriona E.	University of the Philippines Los Baños & Society for the Conservation of Philippine Wetlands, Inc., The Philippines	6.10
Di Luca, Gisela A.	Universidad Nacional del Litoral (UNL) & CONICET, Argentina	6.11

(*Continued*)

Name	Affiliation	Section Numbers
Dotro, Gabriela	Cranfield University, UK	1.1–1.4, 5.4, 5.11, 6.1
Eregno, Fasil Ejigu	The Arctic University of Norway (UiT), Faculty of Engineering Science and Technology, Narvik, Norway & Norwegian Institute of Bioeconomy Research (NIBIO), Ås, Norway	3.1–3.4, 4.8
Esser, Dirk	Société d'Ingénierie Nature &Technique (SINT), France	4.3, 4.10, 4.15, 5.3
Griessler Bulc, Tjaša	University of Ljubljana, Slovenia	4.7, 4.13, 5.10, 6.9
Hadad, Hernán R.	Universidad Nacional del Litoral (UNL) & CONICET, Argentina	6.11
Headley, Tom	Wetland & Ecological Treatment Systems, Australia	4.10, 5.5, 5.9
Heistad, Arve	Norwegian University of Life Sciences (NMBU), Ås, Norway	3.1–3.4
Istenič, Darja	University of Ljubljana, Slovenia	4.7, 4.13, 5.10, 6.9
Jefferson, Bruce	Cranfield University, UK	5.11
Kõiv-Vainik, Margit	University of Tartu, Estonia	5.11
Krivograd Klemenčič, Aleksandra	University of Ljubljana, Slovenia	4.13, 6.9
Langergraber, Günter	BOKU University Vienna, Austria	1.1–1.4, 2.1–2.3, 3.1–3.4, 5.2, 6.1
Lavrnić, Stevo	University of Bologna, Italy	4.5, 6.3
Lecciones, Aaron Julius M.	University of the Philippines Los Baños & Society for the Conservation of Philippine Wetlands, Inc., The Philippines	6.10
Lecciones, Amy M.	Society for the Conservation of Philippine Wetlands, Inc., The Philippines	6.10
Maine, María A.	Universidad Nacional del Litoral (UNL) & CONICET, Argentina	6.11
Marzo, Alessia	University of Catania, Italy	4.7, 4.11.4, 4.11.5, 5.4
Masi, Fabio	Iridra Srl, Florence, Italy	2.1–2.3, 4.11.6, 4.16, 5.2, 5.12, 6.6, 6.7, 6.8
Mæhlum, Trond	Norwegian Institute of Bioeconomy Research (NIBIO), Ås, Norway	4.8
Meney, Kathy	Syrinx Environmental, Australia	6.4
Milani, Mirco	University of Catania, Italy	4.7, 4.11.4, 4.11.5, 5.4
Molle, Pascal	IRSTEA, Villeurbanne, France	5.3, 5.11
Mufarrege, María M.	Universidad Nacional del Litoral (UNL) & CONICET, Argentina	6.11
Nielsen, Steen	Orbicon, Denmark	4.6, 5.6

(*Continued*)

Name	Affiliation	Section Numbers
Nivala, Jaime	Helmholtz Center for Environmental Research – UFZ, Germany	1.1–1.4, 4.8, 4.9, 6.1
Pálfy, Tamás Gábor	University of Sopron, Hungary & IRSTEA, Villeurbanne, France	4.4
Pantelic, Ljiljana	Syrinx Environmental, Australia	6.4
Paruch, Adam M.	Norwegian Institute of Bioeconomy Research (NIBIO), Ås, Norway	4.8
Platzer, Christoph	Rotaria do Brasil, Brazil	4.2
Prigent, Stephane	Bauer Nimr LLC, Muscat, Oman	6.5
Prudente, Ma. Cheryl F.	Society for the Conservation of Philippine Wetlands, Inc., The Philippines	6.10
Pucher, Bernhard	BOKU University Vienna, Austria	5.2
Quintos, Jose Carlo H.	Society for the Conservation of Philippine Wetlands, Inc., The Philippines	6.10
Regelsberger, Martin	Technisches Büro Regelsberger, Gleisdorf, Austria	2.1–2.3, 3.1–3.4, 4.16
Rizzo, Anacleto	Iridra S.r.l., Florence, Italy	4.4, 4.11.6, 4.16, 5.12, 6.6, 6.7, 6.8
Rous, Vit	Czech University of Life Sciences, Prague, Czech Republic	4.11.2, 5.2
Sánchez, Gabriela C.	Universidad Nacional del Litoral (UNL) & CONICET, Argentina	6.11
Schwarzer, Claudia	Bio Piscinas Lda., Aljezur, Portugal	4.15
Schwarzer, Udo	Bio Piscinas Lda., Aljezur, Portugal	4.15
Solimando, Domenico	Consorzio di Bonifica Canale Emiliano Romagnolo, Bologna, Italy	6.3
Stefanakis, Alexandros	Bauer Nimr LLC, Muscat, Oman	4.6, 4.11.1, 4.11.3, 4.12, 5.2, 5.5, 5.6, 5.7, 6.5
Stein, Otto	Montana State University, USA	1.1–1.4, 6.1
Tondera, Katharina	IMT Atlantique, Nantes, France	4.3, 4.4, 5.9, 6.2
Toscano, Attilio	University of Bologna, Italy	4.5, 6.3
Troesch, Stéphane	Eco Bird, Chaponost, France	4.3
van Oirschot, Dion	Rietland bvba, Belgium	5.7
von Sperling, Marcos	Federal University of Minas Gerais, Brazil	4.2
Vymazal, Jan	Czech University of Life Sciences, Prague, Czech Republic	5.4
Wallace, Scott	Naturally Wallace Consulting, USA	5.7, 5.8
Weber, Kela P.	Royal Military College of Canada, Kingston, Canada	4.9
Yang, Lei	National Sun Yat-sen University, Kaohsiung, Taiwan	4.14

4.11.4 Citrus wastewater

Alessia Marzo and Mirco Milani

Department of Agriculture, Food and Environment (Di3A), University of Catania, Via Santa Sofia 100, Catania 95123, Italy

Design objectives

The main design objectives of citrus wastewater treatment is to reduce the TSS, organic matter and essential oil concentrations. Citrus processing wastewater (water for fruit, plants, devices and floors washing, cooling, essential oil extraction and peel drying) is characterized by (Koppar & Pullammanappallil, 2013; Zema *et al*., 2012):

- Seasonal quantitative and qualitative variability;
- Low pH (generally <5);
- High organic matter (COD ranging from about 60–170,000 mg/L);
- High TSS (up to 70,000 mg/L);
- Lack of nutrients (nitrogen and phosphorus);
- High essential oil content (up to 600 mg/L).

Processes required and TW type to be used

Citrus wastewater is usually treated in intensive biological plants, mainly represented by activated sludge systems, which can suffer due to the lack of nutrients and presence of inhibiting compounds (essential oils, polyphenols, etc.). Treatment with a combination of aerobic–anaerobic aerated lagoons and multi-stage wetlands has proved to be a valid alternative to conventional plants thanks to their higher reliability and lower energy requirements.

In aerated lagoons, citrus wastewater is usually stored in large and deep basins with storage capacities of about 50% of the annual volume of produced wastewater and hydraulic retention times longer than 3–6 weeks. Processes in the lagooning treatment include (Andiloro *et al*., 2013):

- An equalization of quali-quantitative wastewater characteristics;
- A progressive increase of pH due to degradation of organic acids;
- A strong reduction of settleable and suspended solids due to flocculation and sedimentation processes; and
- A reduction of essential oils (EOs) concentration by the dilution effect within the lagoon and the biological degradation.

The treatment of lagoon effluent using a multi-stage wetland (HF–VF–FWS) is necessary to reduce the organic and TSS concentrations with filtration, sedimentation, mineralization and anaerobic degradation processes.

Specific considerations during design and for construction

- *Malfunctioning prevention.* High EO concentrations could inhibit biological processes. For this reason, it is advisable to treat wastewater with high EO concentrations in a separated lagoon to further improve efficiency and reliability through the whole cycle.
- *O&M.* Fertilizer may be applied on wetland surface area to promote macrophyte growth after planting.
- *Monitoring.* It is advisable to perform monitoring of pH values in the lagoon systems to evaluate a possible correction of low pH by lime addition or similar alkaline chemicals.

Water quality standards across the world are being re-written to promote healthier ecosystems, ensure safe potable water sources, increased biodiversity, and enhanced ecological functions. Treatment wetlands are used for treating a variety of pollutant waters, including municipal wastewater, agricultural and urban runoff, industrial effluents, and combined sewer overflows, among others. Treatment wetlands are particularly well-suited for sustainable water management because they can cope with variable influent loads, can be constructed of local materials, have low operations and maintenance requirements compared to other treatment technologies, and they can provide additional ecosystem services. The technology has been successfully implemented in both developed and developing countries.

The first IWA Scientific and Technical Report (STR) on Wetland Technology was published in 2000. With the exponential development of the technology since then, the generation of a new STR was facilitated by the IWA Task Group on Mainstreaming Wetland Technology. This STR was conceptualized and written by leading experts in the field. The new report presents the latest technology applications within an innovative planning framework of multi-purpose wetland design. It also includes practical design information collected from over twenty years of experience from practitioners and academics, covering experiments at laboratory and pilot-scale up to full-scale applications.

iwapublishing.com
@IWAPublishing

ISBN: 9781789060164 (Paperback)
ISBN: 9781789060171 (eBook)
ISBN: 9781789060188 (ePub)

ISBN 978-1-78906-016-4
90000
9 781789 060164