# Constructed Wetlands in Africa / Developing countries

University of Natural Resources and Life Sciences, Vienna
Department of
Water, Atmosphere, and Environment

**Günter Langergraber**

Institute of Sanitary Engineering and
Water Pollution Control

Secretary of IWA SG on
***"Wetland Systems for Water Pollution Control"***

*3rd IWA Development Congress*
*14-17 October 2013*
*Nairobi, Kenya*

# Constructed wetlands in Africa

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## Session 1 (09:30-11:00)

- Introduction to Constructed Wetland technology and latest developments (**Guenter Langergraber, Austria**)
- Practical experiences with implementing CWs in Uganda (**Markus Lechner, Austria**)

# Constructed wetlands in developing countries

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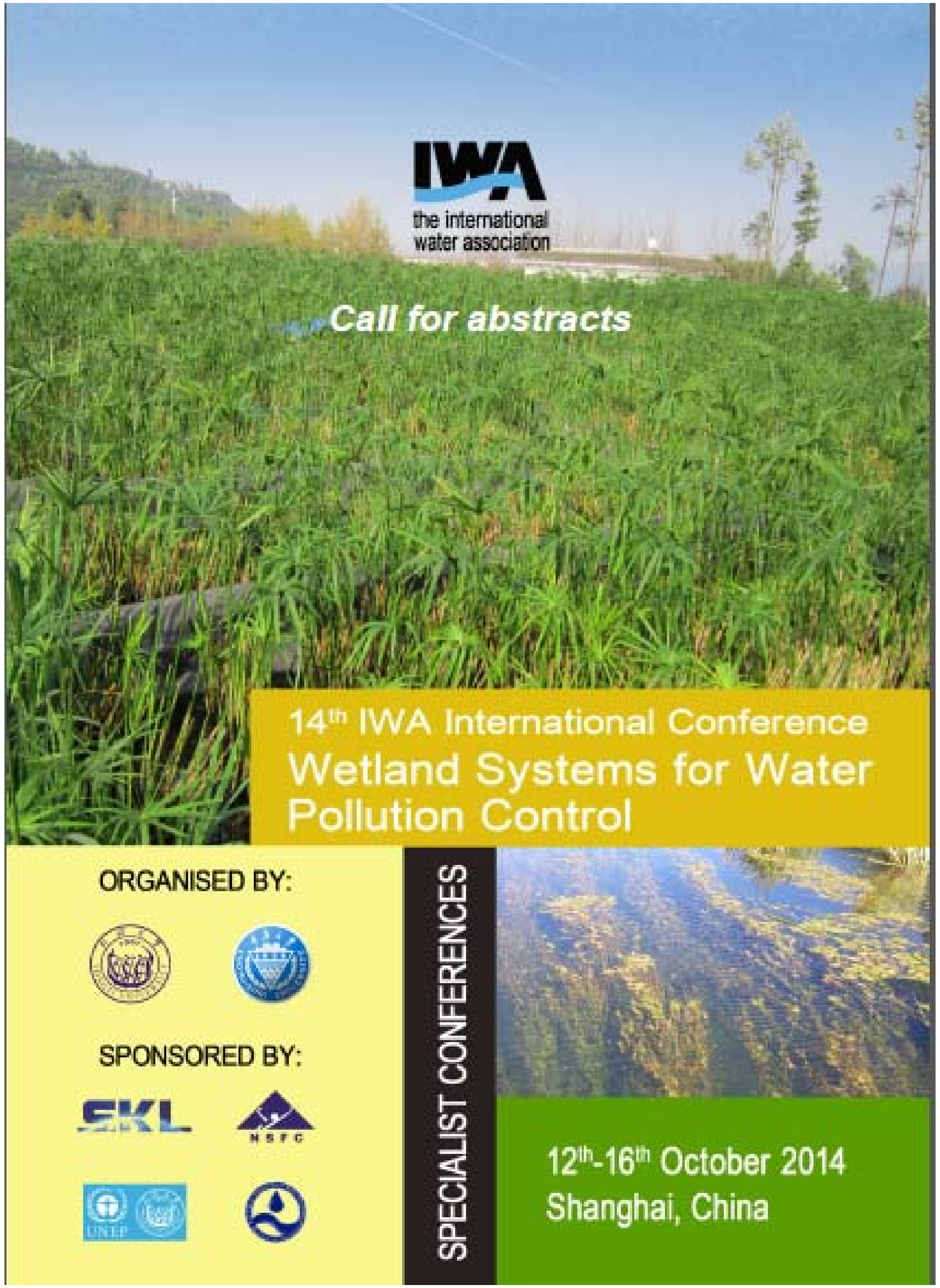
## Session 2 (11:30-13:00)

- A simple, economic and efficient treatment solution for small communities in the State of Bahia (**Agostina Chiavola, Italy**)
- Is it possible to treat faecal sludge of Ouagadougouon with constructed wetlands planted with two plants species (**Tadjouwa Kouawa, Burkina Faso**)
- Utilization of a single-stage vertical flow constructed wetland to treat raw domestic sewage in a developing country (**Elias Sete Manjate, Brazil**)
- Discussion on up-scaling CWs use in developing countries

# Next SG event

14th IWA Conference on Wetland Systems for Water Pollution Control, **12-16 October 2014, Shanghai**, China

- Deadline for abstract submission: **30 Jan 2014**
- **http://www.iwawetland2014.org/**



# Introduction to Constructed Wetland technology

University of Natural Resources and Life Sciences, Vienna
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# Content

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- Introduction
  - Constructed treatment wetlands
  - Sustainable implementation of sanitation systems
- CWs and the SuSanA sustainability criteria
- Practical experiences with CWs (in Austria)
- Summary
- Survey on CWs in East Africa
- Conclusions

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# Introduction

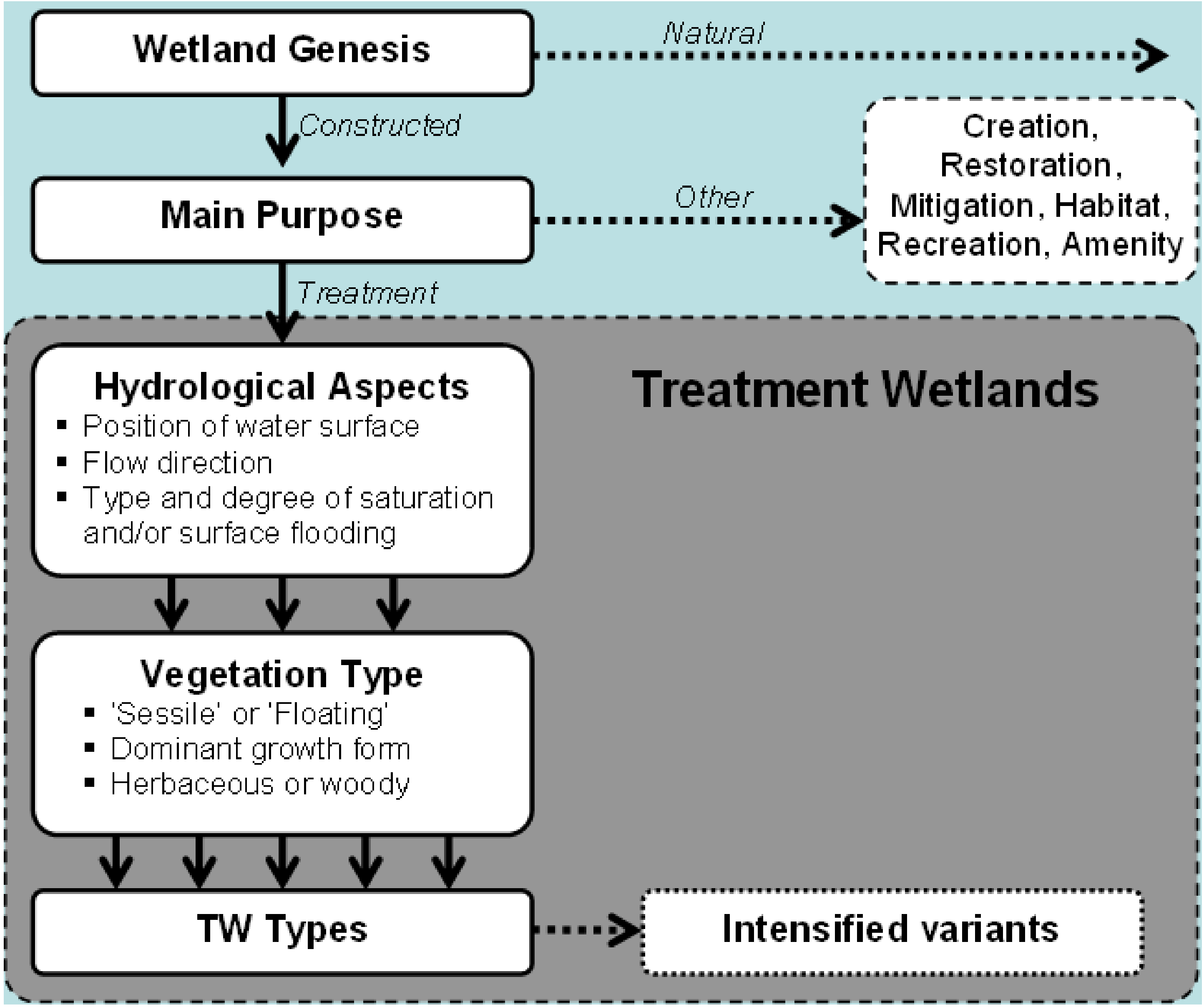
## Types of wetlands (Fonder and Headley, 2010)

- **Natural wetlands** are those wetland areas that exist in the landscape due to natural processes rather than having been created either directly or indirectly as a result of anthropogenic influences.
- **Constructed wetlands** are man-made systems that are designed to mimic many of the conditions and/or processes that occur in natural wetlands.

  Purpose of constructed wetlands:

  - **Restored wetlands**: Areas which were formerly natural wetlands
  - **Created wetlands**: Non-wetland areas which have been converted
  - **Treatment wetlands**: Artificially created wetland systems designed to provide a specific water treatment function

# Introduction
## Types of wetlands




Fonder and Headley (2010)

# Introduction

**Treatment wetlands (Fonder and Headley, 2010)**

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3 characteristics can be identified which are typical of all TWs:

- The presence of **macrophytic vegetation** that typically grows within natural wetlands;
- The existence of **water-logged** or **saturated substrate** conditions for at least part of the time; and
- The inflow of **contaminated waters** with constituents that have to be removed.

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# Introduction

## Classification of TWs (Fonder and Headley, 2010)

| Physical Attribute | Specific Trait | Description | Defined Classes for each trait | Sub-class |
|---|---|---|---|---|
| Hydrology | a. Water position | Position of water surface relative to soil or substrate | Surface Flow[a] | - |
| | | | Subsurface Flow[b] | - |
| | b. Flow direction | Predominant direction of flow through system | Horizontal | - |
| | | | Vertical[c] | Down |
| | | | | Up |
| | | | | Mixed |
| | c. Saturation of media[c] | Degree of saturation in media-based systems | Free-draining | - |
| | | | Intermittent | - |
| | | | Constant | - |
| | d. Surface flooding[c] | Type of surface flooding in media-based systems | None | - |
| | | | Ephemeral | - |
| | | | Permanent | - |
| Vegetation | a. Sessility[d] | Location of the roots: attached in the benthic sediments or floating | Sessile (benthic bound) | - |
| | | | Floating | - |
| | b. Growth Form | Dominant growth form of the vegetation in relation to the water | Emergent | Herbaceous |
| | | | | Woody |
| | | | Submerged[d] | - |
| | | | Floating leaved[d] | - |
| | | | Free-floating[d] | - |

# Introduction
## TW main types

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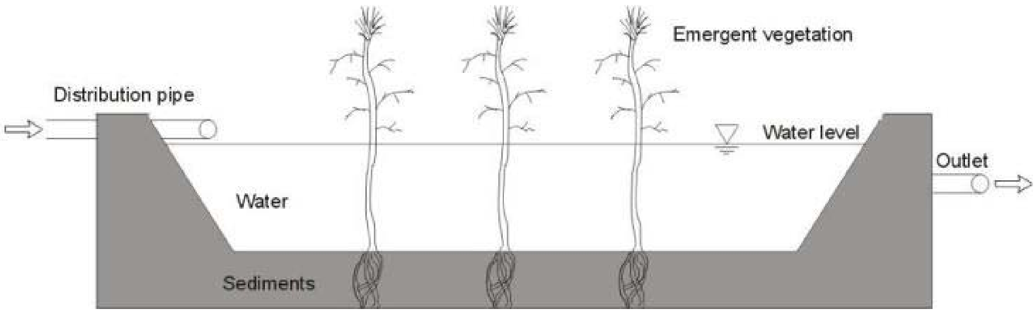
- surface flow

(free water surface)



# FWS CW Poltsamaa, Estonia
# 7500 PE, Area= 12,000 m$^2$

Photo: Otto Stein

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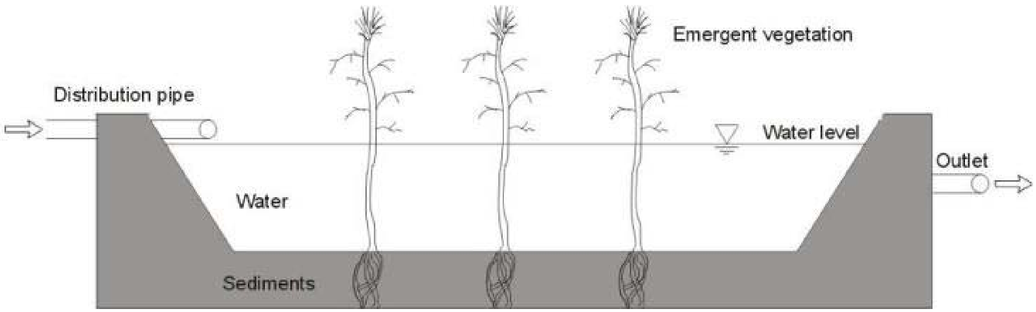
# Introduction
## TW main types

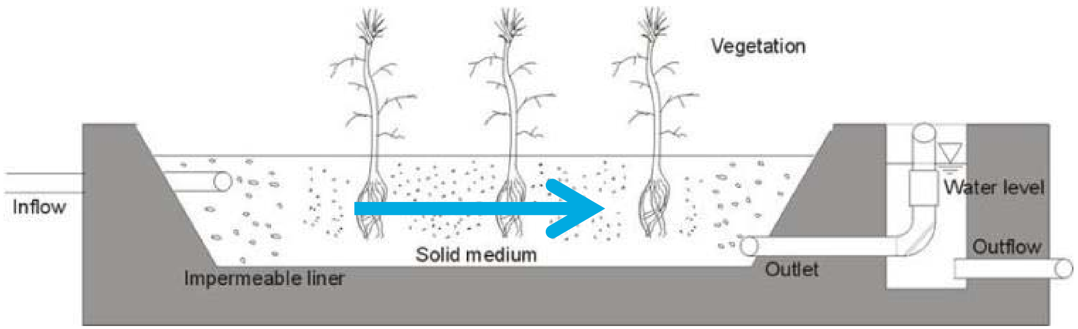
- surface flow

(free water surface)

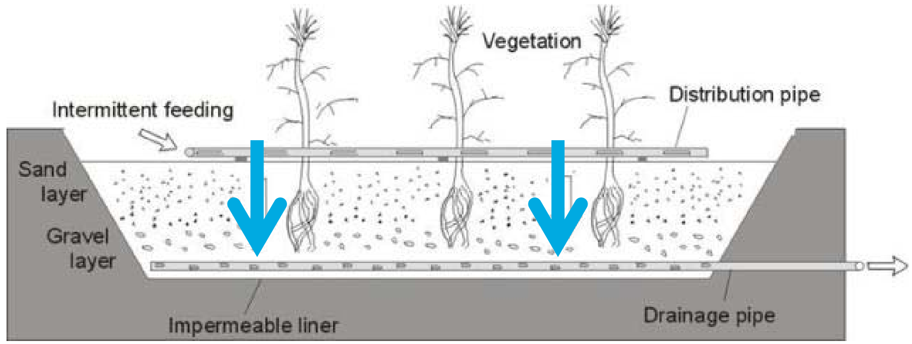



- subsurface flow

horizontal flow




vertical flow with intermittent loading



# Introduction

## Classification of TWs (Fonder and Headley, 2010)

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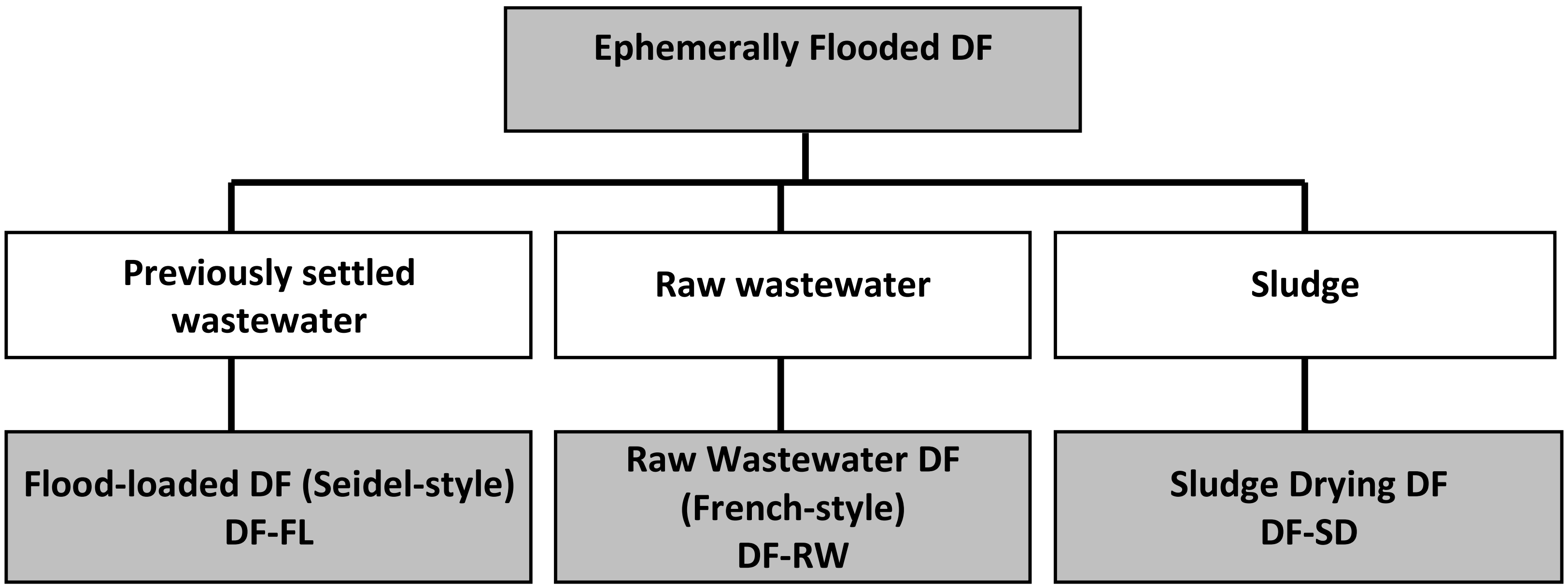
## Variants of VF TWs based on Specific Application



# HF CW Slavošovice, Czech Republic
150 PE, Area= 748 $m^2$ June 2005

Photo Courtesy of Jan Vymazal


2-stage VF CW
40 PE, Austria
August 2010


2-stage VF CW
40 PE, Austria
December 2010


2-stage VF CW
40 PE, Austria
July 2012

# Introduction

## TW main types and characteristics

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| Surface flow | Subsurface HORIZONTAL flow | Subsurface VERTICAL flow |
|---|---|---|
| ▪ Free water surface | ▪ No water on surface | ▪ No water on surface (except for short time during loading) |
| ▪ Overland flow | ▪ Saturated flow conditions only | ▪ Transient variably-saturated flow |
| ▪ Loading is low | ▪ Loading is high | ▪ Loading is higher |
| ▪ Plants significantly contribute to removal of N&P | ▪ Plants can contribute to removal of N&P | ▪ Plants hardly contribute to removal of N&P |
| ▪ Vegetation influences flow | ▪ Only roots influence water flow | ▪ Only roots influence water flow |

Water flow and processes similar as in natural wetlands

# Introduction

## Sustainable sanitation

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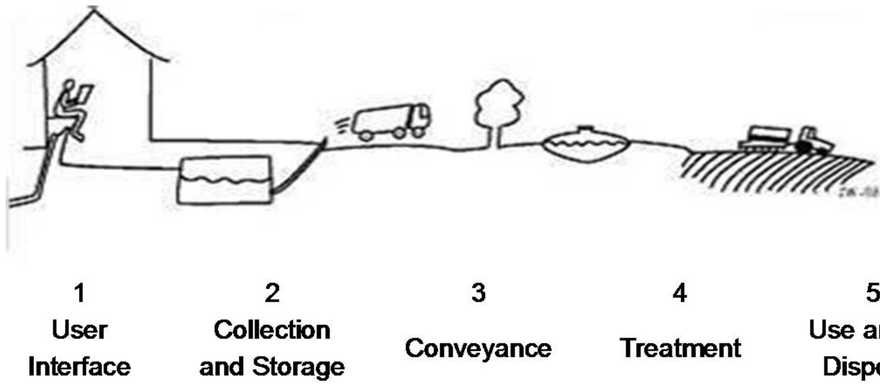
- For sustainable implementation of sanitation systems the **whole sanitation system** has to be kept in mind.
- The five functional groups that form sanitation systems are defined *:
  1. User Interface
  2. Collection and Storage
  3. Conveyance
  4. Treatment
  5. Use and/or Disposal




Sanitation system approach

* Tilley et al., 2008: "*Compendium of Sanitation Systems and Technologies*", EAWAG

# Introduction

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**Sustainable Sanitation Alliance (SuSanA), www.susana.org**

- SuSanA is a loose, dynamic network of organisations working along the same lines → further organisations are welcome to join
- Goal: to **contribute to the achievement of the MDGs by promoting sanitation systems which take into consideration all aspects of sustainability**, i.e. health and hygiene, environmental and natural resources, technology and operation, finance and economics, socio-cultural and institutional (SuSanA vision document, 2007)
- **www.susana.org:** Hugh resources database, SuSanA discussion forum, etc.
- All partnering organisations contribute their work and resources on their own expense
- SuSanA currently has about 10 thematic working groups

# The SuSanA O&M WG

### Fact sheet

Key considerations (for designing sustainable O&M services):

- The **level of O&M** is linked to **ownership** of a facility and the basic **understanding** of the technology and its functions.
- **Every technology** implemented in a sanitation system chain **requires proper O&M** to function.
- **Different technologies** at different steps of the sanitation chain need different people and different responsibilities for O&M.
- Clear **defined roles and accountabilities** as well as appropriate support and training are essential.
- **Institutional responsibilities** as well as effective mechanisms for **cost recovery** are needed.

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sustainable sanitation alliance

SuSanA – factsheet

Operation and maintenance of sustainable sanitation systems

Version 2 (December 2010)

**Key messages**

1. Operation and maintenance (O&M) is of paramount importance for the durable implementation and function of sanitation systems, however it is often neglected.
2. Level of O&M is highly linked to ownership of a facility and the basic understanding of the technology and its functions.
3. Every technology that is implemented in a sanitation system requires proper O&M to function.
4. Different technologies at different steps of the sanitation chain need different people and different responsibilities for O&M.
5. Institutional responsibilities as well as effective mechanisms for cost recovery are needed to ensure sustainable O&M.

**Aims of this factsheet**

The aims of this factsheet are to introduce possible concepts of O&M for sustainable sanitation systems and to show successful implemented examples for O&M.

The target group for this fact sheet consists of sanitation practitioners, researchers and policy makers, as well as of development practitioners who are less familiar with the topic of O&M of sanitation systems. Readers are also referred to the factsheets of other working groups of SuSanA, e.g. costs and economics, productive sanitation systems.

**Introduction**

Appropriate sanitation facilities can provide critical improvement in community health, education, poverty and many other interlinked issues. However, maximum benefits will only be achieved when the sanitation facilities operate continuously and at full capacity in conformity with acceptable standards of quantity and quality. Accordingly, O&M tasks must be carried out effectively and efficiently.

In practise, O&M of sanitation systems receives less attention compared to the design and construction phases, or it is even completely neglected. Especially in developing countries, O&M of decentralised sanitation systems is neglected to a great extent. Among the consequences are poor or non-functioning systems that damage the environment and people's health. Without proper O&M, well designed and nicely constructed infrastructure will sooner or later break down.

Reasons for non-functioning O&M

The reasons for non-functioning O&M services range from a lack of ownership or delegated responsibility for O&M, or a lack of skilled labour, and high operating costs to excessive repair and replacement expenses. Additionally, the technical options chosen are not always the best suited to the environment in which they shall be operated. Other reasons are closely related to the set-up of projects, which often focus only on construction of hardware instead of software components, because it is simpler and less time consuming. Consultation with the local stakeholder and users regarding the most appropriate system for the local conditions is often low.

In most cases where the provision of sanitation services has failed, the root causes have been poor management, lack of planning and failure to generate revenue sufficient to operate and maintain systems (Brikutefler, 2007).

It is obvious the "*efficient and effective management of the system is most essential for their proper functioning*" (Oldenburg, et al., 2009). It is therefore indispensable that O&M of sanitation systems has to be seen in a holistic conceptual framework of sanitation planning. Tasks and responsibilities have to be made abundantly clear and divided among the involved actors/stakeholders e.g. between the municipality, CBOs, users and the private sector. Thus governments and external support agencies are starting to recognize the importance of integrating O&M components in all development phases of water supply and sanitation projects (Brikké and Bredero, 2003).

Version 2 (December 2010) Page 1 of 8

# CWs and the SuSanA sustainability criteria

- When improving an existing and/or designing a new sanitation system, **sustainability criteria** related to the following aspects should be considered:
  - **Health and hygiene**
  - **Environment and natural resources**
  - **Technology and operation**
  - **Financial and economic issues**
  - **Socio-cultural and institutional aspects**
- Sustainable sanitation is key to make an investment in sanitation viable – all five sustainability criteria must be met!

sustainable sanitation alliance

Towards more sustainable sanitation solutions

Version 1.1 (November 2007)

**Introduction**

The urgency for action in the sanitation sector is obvious, considering the 2.6 billion people worldwide who remain without access to any kind of improved sanitation, and the 2.2 million annual deaths (mostly children under the age of 5) caused mainly by sanitation-related diseases and poor hygienic conditions.

The United Nations, during the Millennium Summit in New York in 2000 and the World Summit on Sustainable Development in Johannesburg (WSSD) in 2002, developed a series of Millennium Development Goals (MDGs) aiming to achieve poverty eradication and sustainable development. The specific target set for the provision of water supply and sanitation services is to halve the proportion of people without access to safe drinking water and basic sanitation by 2015.

As the Joint Monitoring Programme of WHO/UNICEF and the UNDP Human Development Report (2006) have shown, the progress towards meeting the MDG sanitation target is however much too slow, with an enormous gap existing between the intended coverage and today's reality especially in Sub-Sahara Africa and parts of Asia.

The reasons for this are numerous. A major issue is the fact that sanitation rarely receives the required attention and priority by politicians and civil society alike despite its key importance for a society. Political will has been largely lacking when it comes to placing sanitation high on the international development agenda. This has pushed sanitation into the shadows of water supply projects for example, and limited innovation in the sector.

Motivated by the UN's decision to declare 2008 as International Year of Sanitation (IYS), a core group of organisations active in the field of sanitation took the initiative to form a task force to support the IYS. In January 2007, a first meeting resulted in a large number of commitments by the participants from various organisations, and in drawing up a first draft of a "joint road map for the promotion of sustainable sanitation in IYS 2008". During a second meeting which took place mid April, the goal and the objectives of this global competence network were clarified and the joint road map was reviewed.

In order to have a joint label for the planned activities, and to be able to align with other potential initiatives, the group formed the "Sustainable Sanitation Alliance (SuSanA)".

**What is sustainable sanitation?**

The main objective of a sanitation system is to protect and promote human health by providing a clean environment and breaking the cycle of disease. In order to be sustainable a sanitation system has to be not only economically viable, socially acceptable, and technically and institutionally appropriate, it should also protect the environment and the natural resources. When improving an existing and/or designing a new sanitation system, sustainability criteria related to the following aspects should be considered:

(1) **Health and hygiene:** includes the risk of exposure to pathogens and hazardous substances that could affect public health at all points of the sanitation system from the toilet via the collection and treatment system to the point of reuse or disposal and downstream populations. This topic also covers aspects such as hygiene, nutrition and improvement of livelihood achieved by the application of a certain sanitation system, as well as downstream effects.

**SuSanA**
**Towards more sustainable sanitation solutions**
Version 1.1 (November 2007)

# CWs and the SuSanA sustainability criteria

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- SuSanA sustainability criteria:
  - Health and hygiene
  - Environment and natural resources
  - Technology and operation
  - Financial and economic issues
  - Socio-cultural and institutional aspects

Langergraber (2013): Are constructed treatment wetlands sustainable sanitation solutions? *Water Sci Technol* 67(10), 2133-2140.

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# CWs and the SuSanA sustainability criteria

- SuSanA sustainability criteria:
  - **Health and hygiene** → reduce pathogens with varying but significant degrees of effectiveness.
  - Environment and natural resources
  - Technology and operation
  - Financial and economic issues
  - Socio-cultural and institutional aspects

Langergraber (2013): Are constructed treatment wetlands sustainable sanitation solutions? *Water Sci Technol* 67(10), 2133-2140.

# CWs and the SuSanA sustainability criteria

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- SuSanA sustainability criteria:
  - Health and hygiene
  - **Environment and natural resources**
  - Technology and operation
  - Financial and economic issues
  - Socio-cultural and institutional aspects

→

- reduced pollution load
- low (or no) energy requirement
- other functions (e.g. biodiversity, water saving, hydrological functions, …)

Langergraber (2013): Are constructed treatment wetlands sustainable sanitation solutions? *Water Sci Technol* 67(10), 2133-2140.

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# CWs and the SuSanA sustainability criteria

- SuSanA sustainability criteria:
  - Health and hygiene
  - Environment and natural resources
  - **Technology and operation** →
  - Financial and economic issues
  - Socio-cultural and institutional aspects

- simple in design, construction and operation
- robust performance, flexible and adaptable

Langergraber (2013): Are constructed treatment wetlands sustainable sanitation solutions? *Water Sci Technol* 67(10), 2133-2140.

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# CWs and the SuSanA sustainability criteria

- SuSanA sustainability criteria:
  - Health and hygiene
  - Environment and natural resources
  - Technology and operation
  - **Financial and economic issues** →
  - Socio-cultural and institutional aspects

- construction costs are in the same range compared to conventional technical treatment plants (in Europe)
- However, O&M costs are lower for CWs due to less energy demand and technical devices used

Langergraber (2013): Are constructed treatment wetlands sustainable sanitation solutions? *Water Sci Technol* 67(10), 2133-2140.

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# CWs and the SuSanA sustainability criteria

- SuSanA sustainability criteria:
  - Health and hygiene
  - Environment and natural resources
  - Technology and operation
  - Financial and economic issues
  - **Socio-cultural and institutional aspects**

→

- more aesthetical appearance
- provision of public use functions
- additional benefits might increase the public acceptability of CWs.

Langergraber (2013): Are constructed treatment wetlands sustainable sanitation solutions? *Water Sci Technol* 67(10), 2133-2140.

# CWs and the SuSanA sustainability criteria

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- SuSanA sustainability criteria:
  - ✓ Health and hygiene
  - ✓ Environment and natural resources
  - ✓ Technology and operation
  - ✓ Financial and economic issues
  - ✓ Socio-cultural and institutional aspects

Langergraber (2013): Are constructed treatment wetlands sustainable sanitation solutions? *Water Sci Technol* 67(10), 2133-2140.

# Practical experiences with CWs

# (from Austria)

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Location of Austria
in World Map
N
NO
KANGAROOS
IN
AUSTRIA
AT
Nairobi
AU
www.mapsofworld.com
Map not to Scale
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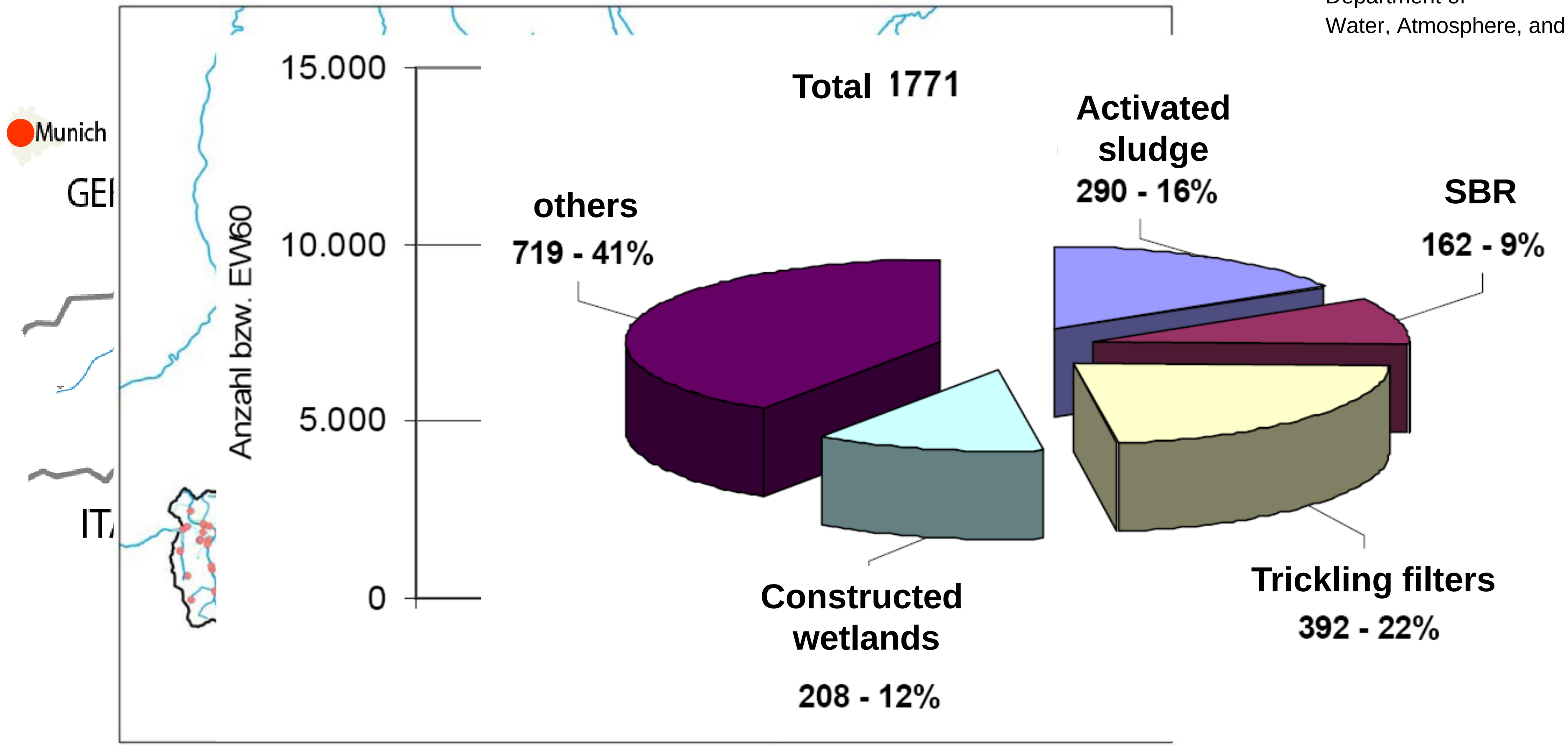
# Practical experiences with CWs

## Example Salzburg (1771 small WWTPs, i.e. < 500 PE)




Schaber, P., Reif, H. (2009): Kleinkläranlagen aus Sicht des Gewässerschutzes im Land Salzburg. *Wiener Mitteilungen* 218, H1-H22.

# Practical experiences with CWs

## Example Salzburg

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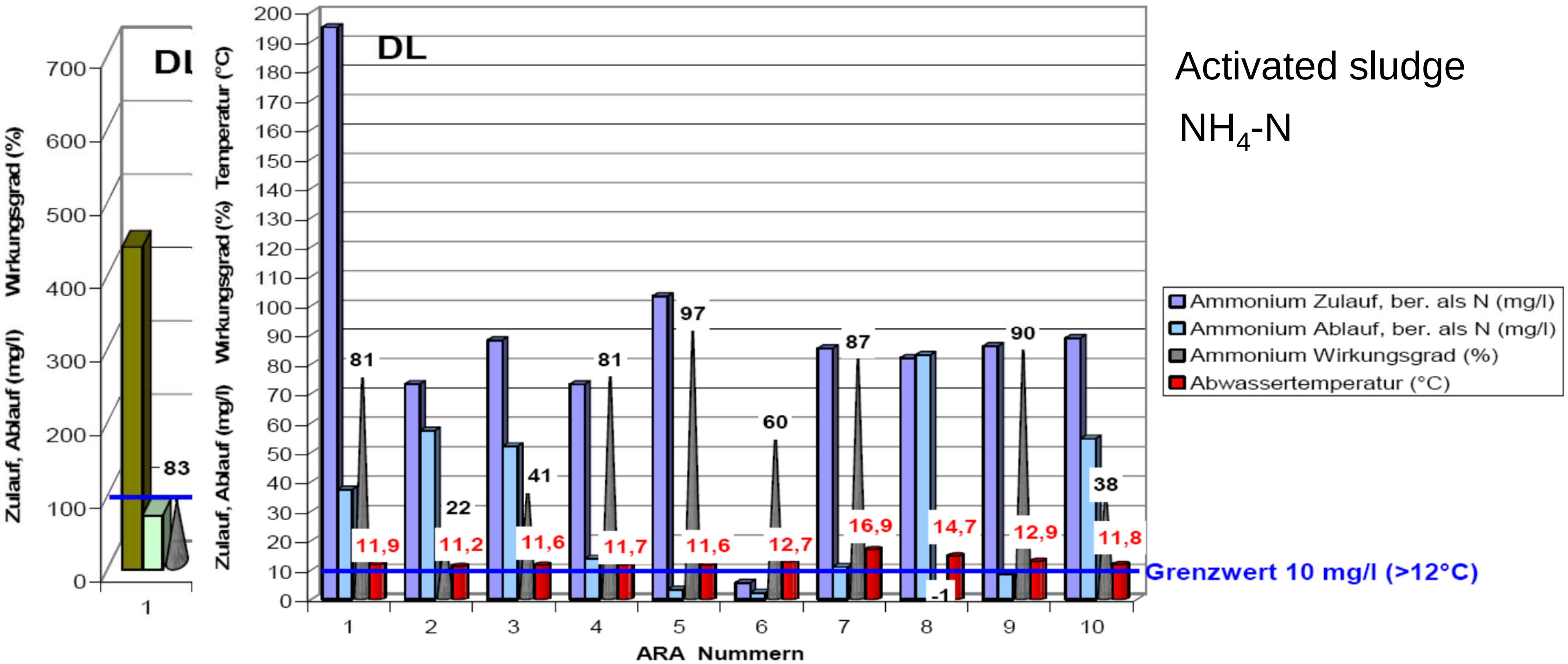


Activated sludge

$NH_4$-N

Schaber, P., Reif, H. (2009): Kleinkläranlagen aus Sicht des Gewässerschutzes im Land Salzburg. *Wiener Mitteilungen* 218, H1-H22.

# Practical experiences with CWs

## Example Salzburg

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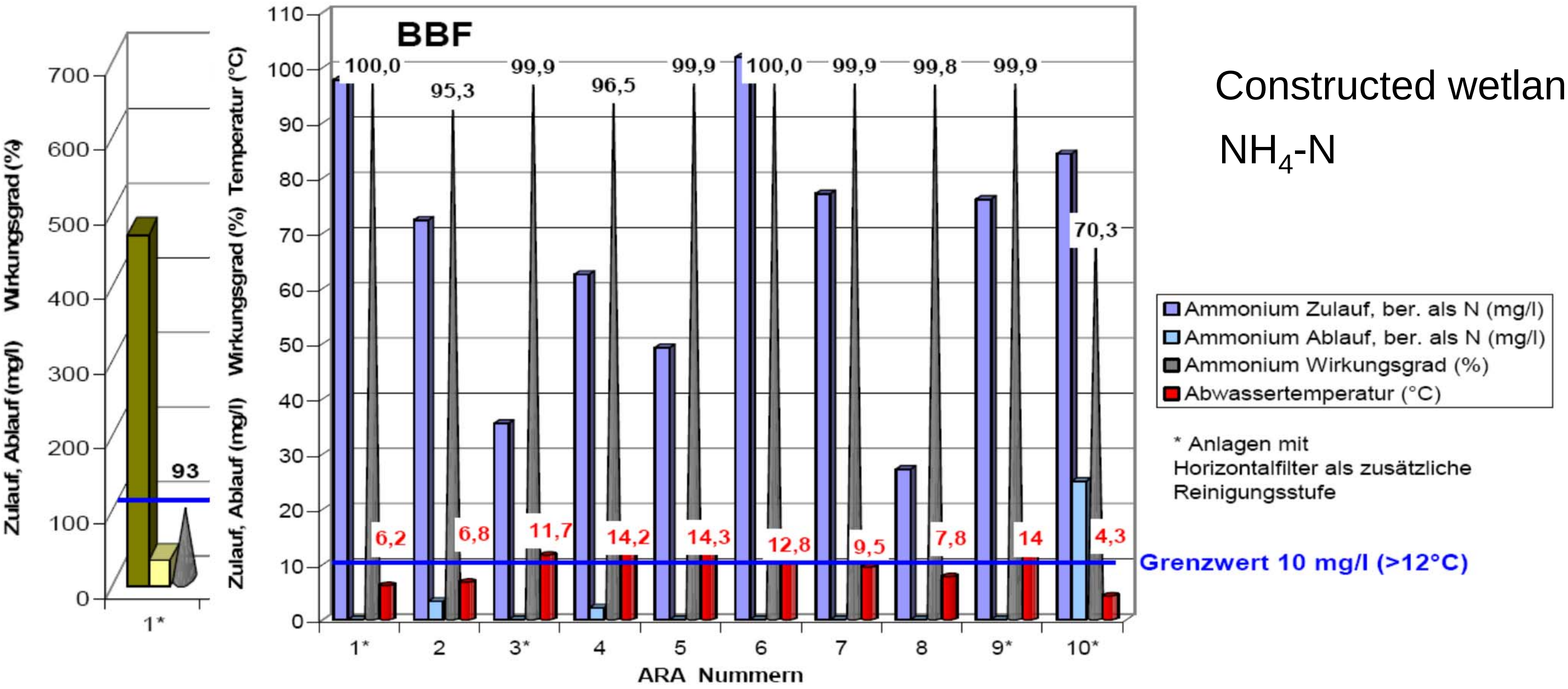


Constructed wetlands

$NH_4$-N

Schaber, P., Reif, H. (2009): Kleinkläranlagen aus Sicht des Gewässerschutzes im Land Salzburg. *Wiener Mitteilungen* 218, H1-H22.

# Practical experiences with CWs

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## Example Salzburg

| Type of WWTP | COD | $BOD_5$ | $NH_4$-N 1) | $NH_4$-N 2) | TSS | Meet all requirements |
|---|---|---|---|---|---|---|
| **Activated sludge** | 4 | 5 | 8 | 3 | 5 | **2** |
| **SBR** | 10 | 10 | 9 | 9 | 8 | **8** |
| **Trickling filter** | 6 | 5 | 7 | 6 | 5 | **2** |
| **Constructed wetland** | 10 | 10 | 10 | 9 | 10 | **10** |

1) considering only measured data for effluent water temperatures > 12°C
2) considering all measured data

Schaber, P., Reif, H. (2009): Kleinkläranlagen aus Sicht des Gewässerschutzes im Land Salzburg. *Wiener Mitteilungen* 218, H1-H22.

# Practical experiences with CWs

## O&M requirements to ensure long-term operation

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- CWs in Austria: 3'000 – 4'000
- Company *Ökologisches Projekt Graz* constructed ca. 1600 CWs in Austria
- They have O&M service contracts for > 800 (small) CWs
- If O&M is carried out by professionals it is more likely to detect problems before they become visible in a reduction of treatment efficiency

Table 2: $NH_4$-N effluent concentrations in 847 samples of 2011

| $NH_4$-N (mg/L) | | | | |
|---|---|---|---|---|
| Category | from | to | n | % |
| 1 | 0 | 1 | 596 | 70 |
| 2 | 1 | 10 | 172 | 20 |
| 3 | 10 | 20 | 50 | 6 |
| 4 | 20 | 30 | 14 | 2 |
| 5 | 30 | 40 | 7 | 1 |
| 6 | >40 | | 8 | 1 |
| Total number of samples: | | | 847 | 100 |

302 samples taken at effluent water temperatures < 12°C

Mitterer-Reichmann (2012): Treatment wetlands in Austria: Practical experiences in planning, construction and maintenance. *Sustainable Sanitation Practice* 12 (July 2012), 4-8 (http://www.ecosan.at/ssp/).

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# Practical experiences with CWs

## O&M requirements to ensure long-term operation

Main O&M problems for VF CWs:

- ***Pre-treatment***: sludge emptying (interval between one year and several years)
- ***Intermittent loading system***: functioning of the intermittent loading by syphon needs to be checked (e.g. rubber part of the flexible pipe can get porous)
- ***Distribution system***: uneven distribution of wastewater most common problem of malfunctioning; distribution system can be best adjusted and cleaned after cutting of the plants.
- ***Wetland plants***: During the first year: removal of weeds until the reed is established, cutting of plants either in spring of autumn

Mitterer-Reichmann (2012): Treatment wetlands in Austria: Practical experiences in planning, construction and maintenance. *Sustainable Sanitation Practice* 12 (July 2012), 4-8 (http://www.ecosan.at/ssp/).

# Conclusions

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- CWs compare quite favourable against the SuSanA sustainability criteria
  - literature review
  - supported by practical examples from Austria

  → CWs have a high potential for being implemented in sustainable sanitation solutions.
- Sustainable implementation of sanitation systems can only be achieved when the whole sanitation service chain is considered.
  - O&M, sludge treatment, reuse, etc. need to be considered when planning CWs in sanitation systems

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Department of
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## Contact

# Dr Guenter Langergraber

University of Natural Resources and Life Sciences, Vienna (BOKU)
Department of Water, Atmosphere and Environment
Institute of Sanitary Engineering and Water Pollution Control

Muthgasse 18, A-1190 Vienna, Austria
Tel.: +43 (0)1 47654-5814, Fax: +43 (0)1 47654-5803
Email: guenter.langergraber@boku.ac.at
http://www.wau.boku.ac.at/sig.html