150 JAHRE
NACHHALTIG
VORAUSSCHAUEN
1872 – 2022

UNIVERSITÄT FÜR BODENKULTUR WIEN

# Natural Solutions for Rural Wastewater Treatment


**Günter Langergraber**

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


Danube Water Conference
"Integrating Green and Grey Infrastructure
for Water Security and Climate Resilience"

20 October 2021

# Content

- Introduction
- Overview on solutions for rural areas
- Performance of small WWTPs < 50 PE
  - Case study Upper Austria
- Conclusions

# Introduction

## Characteristics / requirements in rural areas

### Characteristics

- highly fluctuating wastewater flows, and high concentrations of the wastewater constituents with high fluctuations.
- additionally only few trained personal is available to operate wastewater treatment plants

### → General requirements for small WWTPs in rural areas

- simplicity of the technology,
- simple operation and maintenance,
- high robustness,
- large volume, to buffer the high fluctuations of flow and concentrations,
- high stability, and
- low sludge production

# Overview on solutions for rural areas

**On-site collection with off-site treatment**

- Cesspits (with transport to next WWTP of faecal sludge treatment unit)

**On-site treatment**

- Solutions with less than secondary treatment, e.g. septic tanks, etc.
- Solutions with at least secondary treatment

**Soil as recipient** (of treated or partially treated or untreated wastewater)

- Soak pits, leach fields, etc.

**Resources-oriented sanitation systems**

- Wastewater as resource: e.g. treated water, nutrients, organic nutrients, heat
- Separate collection of wastewater streams, i.e. separation of **blackwater and greywater** and/or **source-separated urine**

→ If owners of WWTPs have an additional benefit besides treatment of wastewater, it is more likely that the WWTPs are operated well

# Overview on solutions for rural areas

**… for secondary treatment**

## Intensive treatment systems

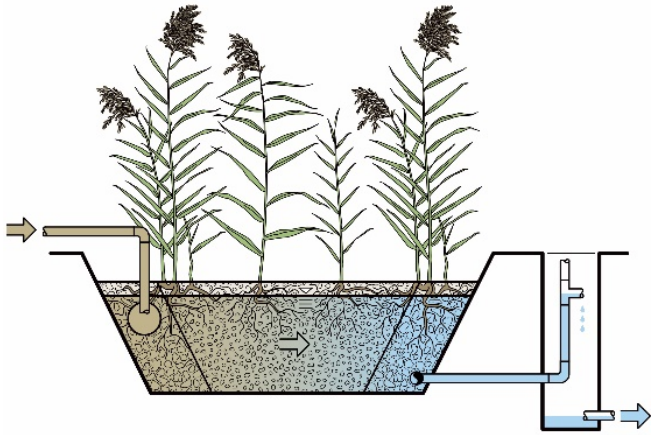
- Technologies with fixed biomass
  - **Trickling filter**
  - **Rotating biological contactor**
  - Soil filter
  - etc.
- Technologies with suspended biomass
  - **CAS** (Conventional activated sludge)
  - **SBR** (Sequencing Batch Reactor)
  - **MBR** (Membrane BioReactor)
  - etc.

## Extensive treatment systems

- **Treatment wetlands**
- Waste stabilization ponds

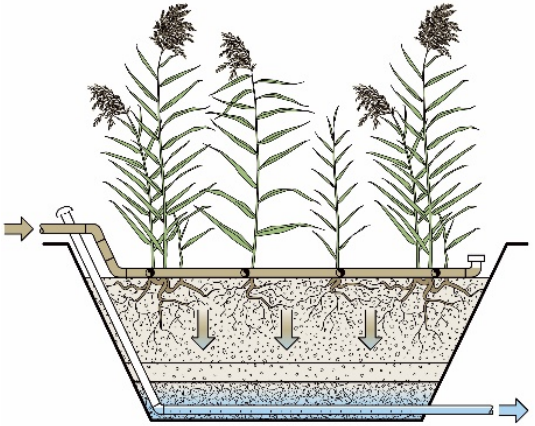
# Overview on solutions for rural areas

## Treatment wetlands main types for at least secondary treatment



### Horizontal flow (HF) wetland

- Due to water-saturated conditions mainly anaerobic degradation processes occur
- Effective primary treatment is required



### Vertical flow (VF) wetland

- Wastewater is intermittently loaded → mainly aerobic degradation processes
- Effective primary treatment is required

Dotro et al., 2017, *Treatment Wetlands*. IWA Publishing, London, UK; http://wio.iwaponline.com/content/16/9781780408774.

# VF wetland (10 PE) in Lower Austria

Picture: Günter Langergraber

# Performance of small WWTPs < 50 PE

## Wastewater treatment in Austria - Basic data

| **Capacity** (PE) | **Number of WWTPs** | % | **Design load** (million PE) | % |
|---|---|---|---|---|
| **51-500** | 1'040 | 54 | 0.18 | 1 |
| **501-5'000** | 505 | 26 | 1.13 | 5 |
| **5'001-50'000** | 316 | 16 | 6.10 | 28 |
| **>50'000** | 66 | 4 | 14.06 | 66 |
| **Total > 50 PE** | **1'927** | **100** | **21.47** | **100** |
| **≤ 50 PE** | ca. **27'500** | - | **0.26** | |

Wastewater treatment plants and design load with capacity > 50 PE (ÖWAV, 2019)

→ 95.2 % of population connected to WWTPs > 50 PE

ÖWAV (2019): Branchenbild der österreichischen Abwasserwirtschaft 2020 (Sector report of Austrian wastewater management 2020). Österreichischer Wasser- und Abfallwirtschaftsverband (ÖWAV), Vienna, Austria [in German]; https://www.oewav.at/Publikationen?current=385139&mode=form

# Performance of small WWTPs < 50 PE

**Case study Upper Austria**

Data provided by the government of Upper Austria

- List of all small WWTPs currently in operation
- Measured data from external monitoring from the period 2009-2018

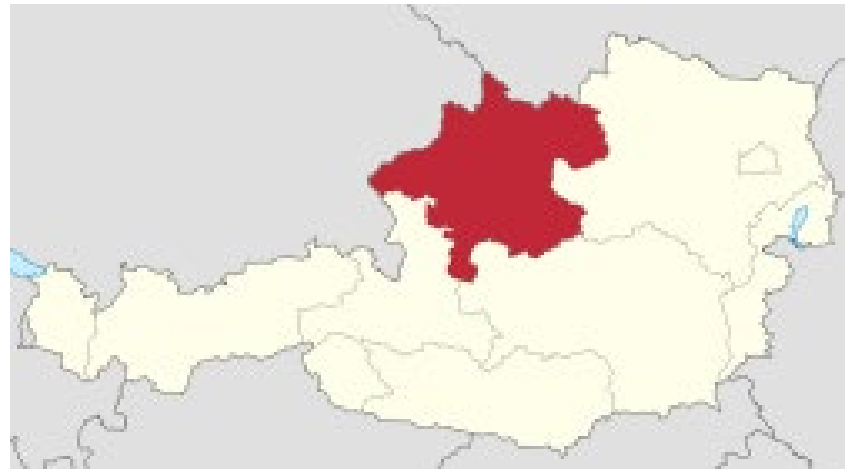
WWTPs have been grouped according on the main treatment step

- Conventional activated sludge (CAS)
- Sequencing batch reactors (SBR)
- Vertical flow wetlands (VF wetland)
- Trickling filter
- Rotating biological contactor (RBC)
- Membrane bioreactor (MBR)
- Soil filter, i.e. Bodenkörperfilter

# Performance of small WWTPs < 50 PE

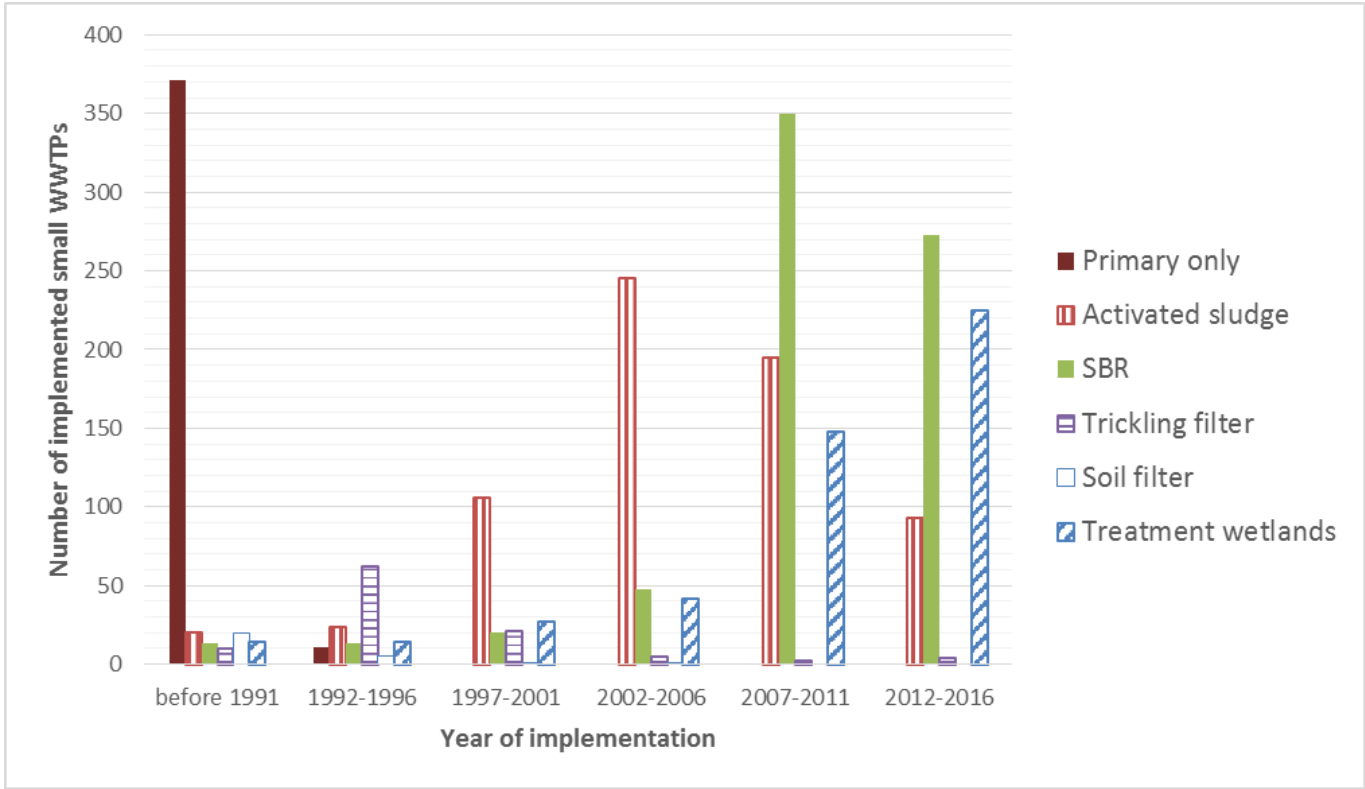
## Number of small WWTPs in Upper Austria

| Technology | # 2016 |
|---|---|
| SBR | 702 |
| CAS | 646 |
| VF wetland | 475 |
| Primary treatment only | 381 |
| Trickling filter | 100 |
| RBC | 37 |
| MBR | 26 |
| Soil filter | 27 |
| Unknown | 4 |
| **Total** | **2'398** |



# Performance of small WWTPs < 50 PE

## Year of commissioning of small WWTPs in Upper Austria




Langergraber, G., Weissenbacher, N. (2017): Survey on number and size distribution of TWs in Austria. *Water Sci Technol* 75(10), 2309-2315.

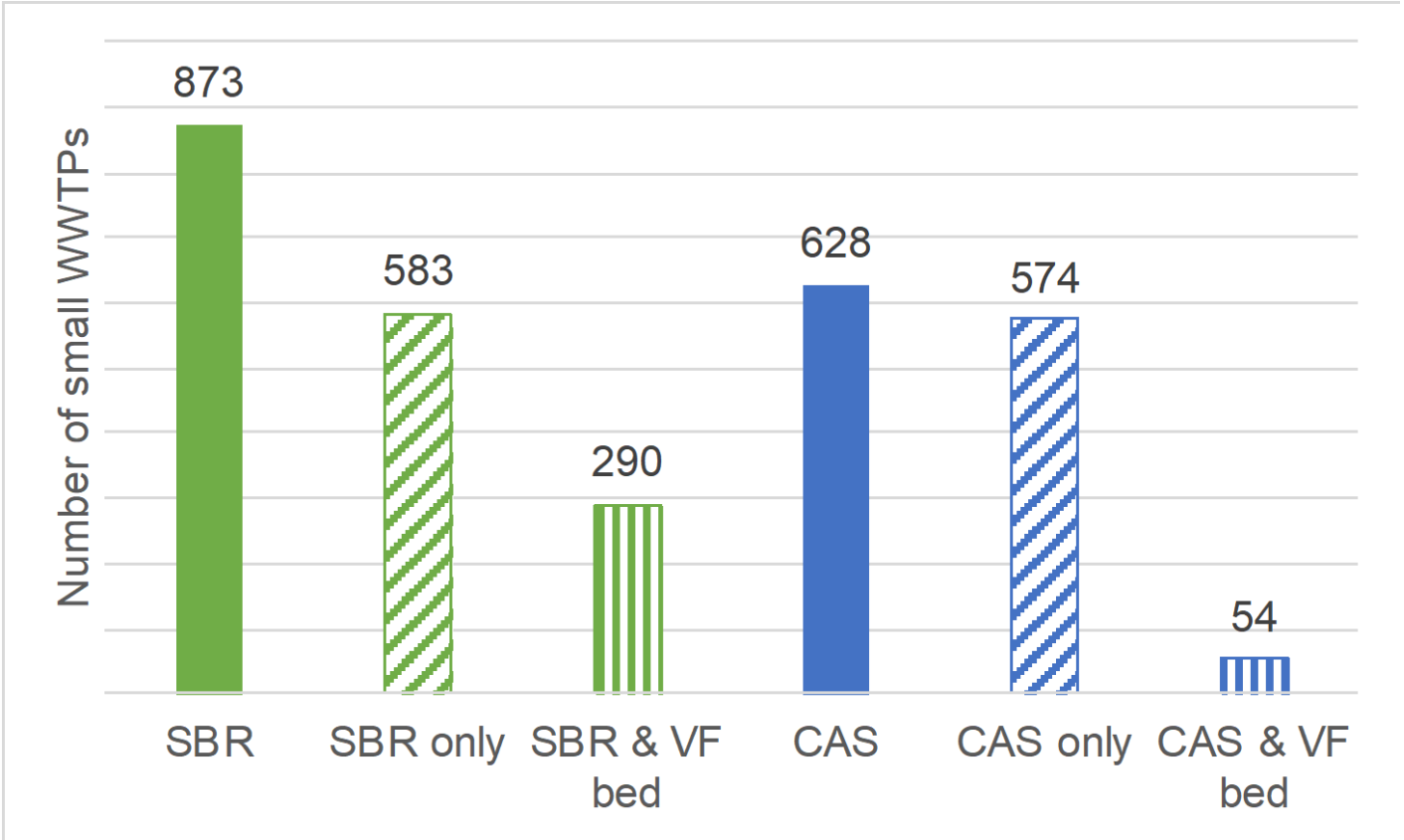
# Performance of small WWTPs < 50 PE

## Number of small WWTPs in Upper Austria

| Technology | # 2016 | # 2019 | Difference |
|---|---|---|---|
| SBR | 702 | 873 | 171 |
| CAS | 646 | 628 | -18 |
| VF wetland | 475 | 535 | 60 |
| Primary treatment only | 381 | 302 | -79 |
| Trickling filter | 100 | 97 | -3 |
| RBC | 37 | 37 | 0 |
| MBR | 26 | 26 | 0 |
| Soil filter | 27 | 27 | 0 |
| Unknown | 4 | 1 | -3 |
| **Total** | **2'398** | **2’526** | **128** |

# Performance of small WWTPs < 50 PE

## Number of small WWTPs in Upper Austria



# SBR + VF bed (50 PE) in Upper Austria

# Performance of small WWTPs < 50 PE

## Case study Upper Austria

| COD [90 mg/l] | | SBR | SBR & VF wetland | CAS | CAS & VF wetland | VF wetland | Trickling filter | RBC | MBR | Soil filter | All data |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of small WWTPs | [ ] | 493 | 252 | 540 | 52 | 491 | 85 | 36 | 25 | 7 | 1'981 |
| Number of values | [ ] | 3'365 | 1'568 | 4'406 | 422 | 3'245 | 703 | 283 | 185 | 54 | 14'231 |

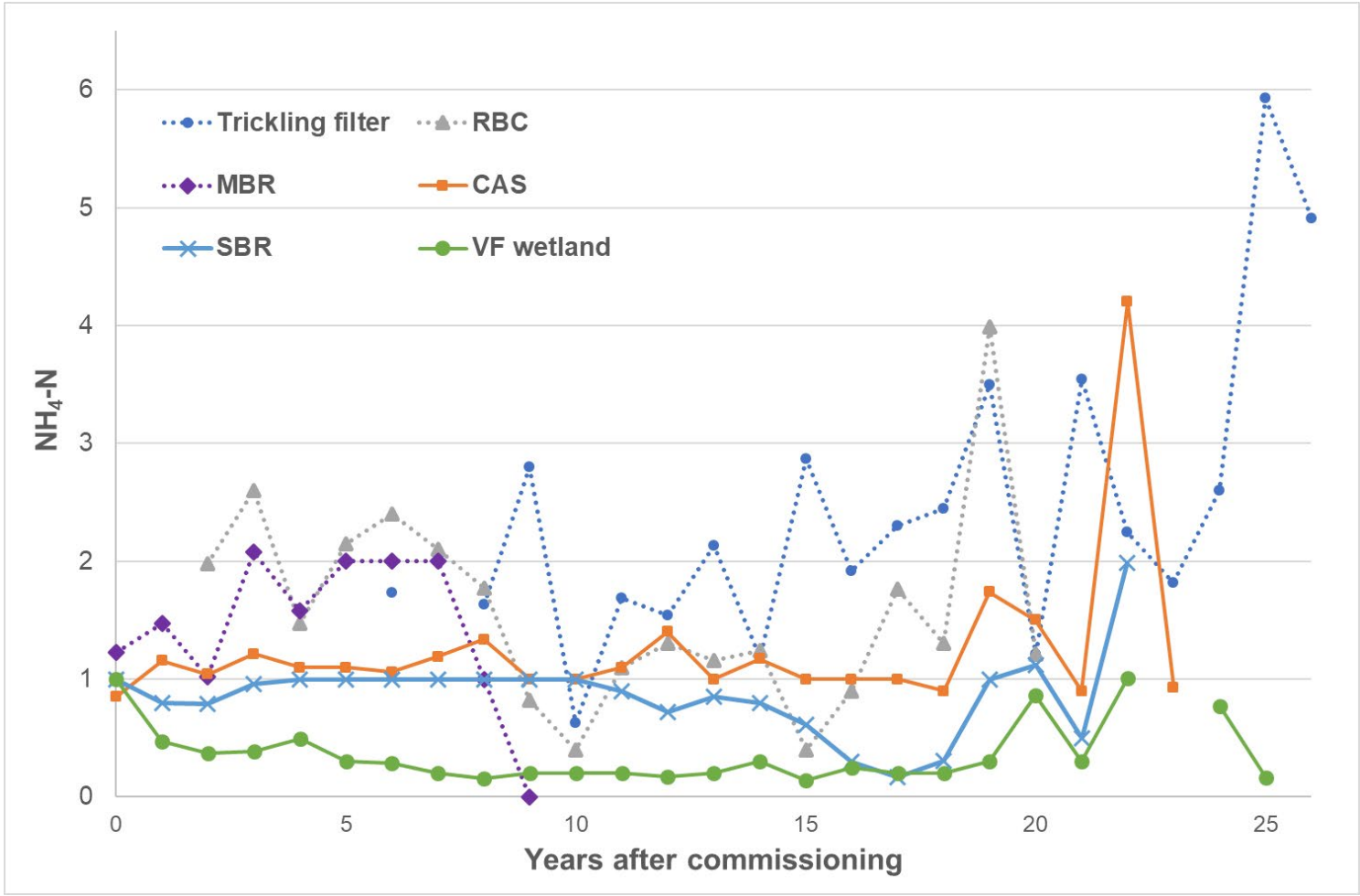
| NH4-N [10 mg/l] | | SBR | SBR & VF wetland | CAS | CAS & VF wetland | VF wetland | Trickling filter | RBC | MBR | Soil filter | All data |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of small WWTPs | [ ] | 493 | 252 | 540 | 52 | 491 | 85 | 36 | 25 | 7 | 1'981 |
| Number of values | [ ] | 3'347 | 1'565 | 4'382 | 418 | 3'199 | 689 | 282 | 184 | 54 | 14'120 |
| Values above threshold | [ ] | 72 | 13 | 137 | 9 | 48 | 42 | 17 | 6 | 6 | 350 |
| | [%] | 2.2 | 0.8 | 3.1 | 2.2 | 1.5 | 6.1 | 6.0 | 3.3 | 11.1 | 2.5 |
| **Median** | **[mg/l]** | **1.00** | **0.68** | **1.09** | **0.24** | **0.37** | **2.20** | **1.2** | **1.78** | **2.66** | **0.98** |
| Mean | [mg/l] | 2.43 | 1.14 | 2.95 | 1.54 | 1.43 | 4.21 | 3.48 | 2.52 | 4.23 | 2.31 |
| Standard deviation | [mg/l] | 5.08 | 2.35 | 5.85 | 4.19 | 2.91 | 6.18 | 6.17 | 3.99 | 4.69 | 4.84 |

Engstler, E., Kerschbaumer, D., Langergraber, G. (2019): Evaluierung von Kleinkläranlagen anhand der Fremdüberwachungsdaten. *Wiener Mitteilungen* 251, B1-B13.

# Performance of small WWTPs < 50 PE

## Performance related to the age of the plant

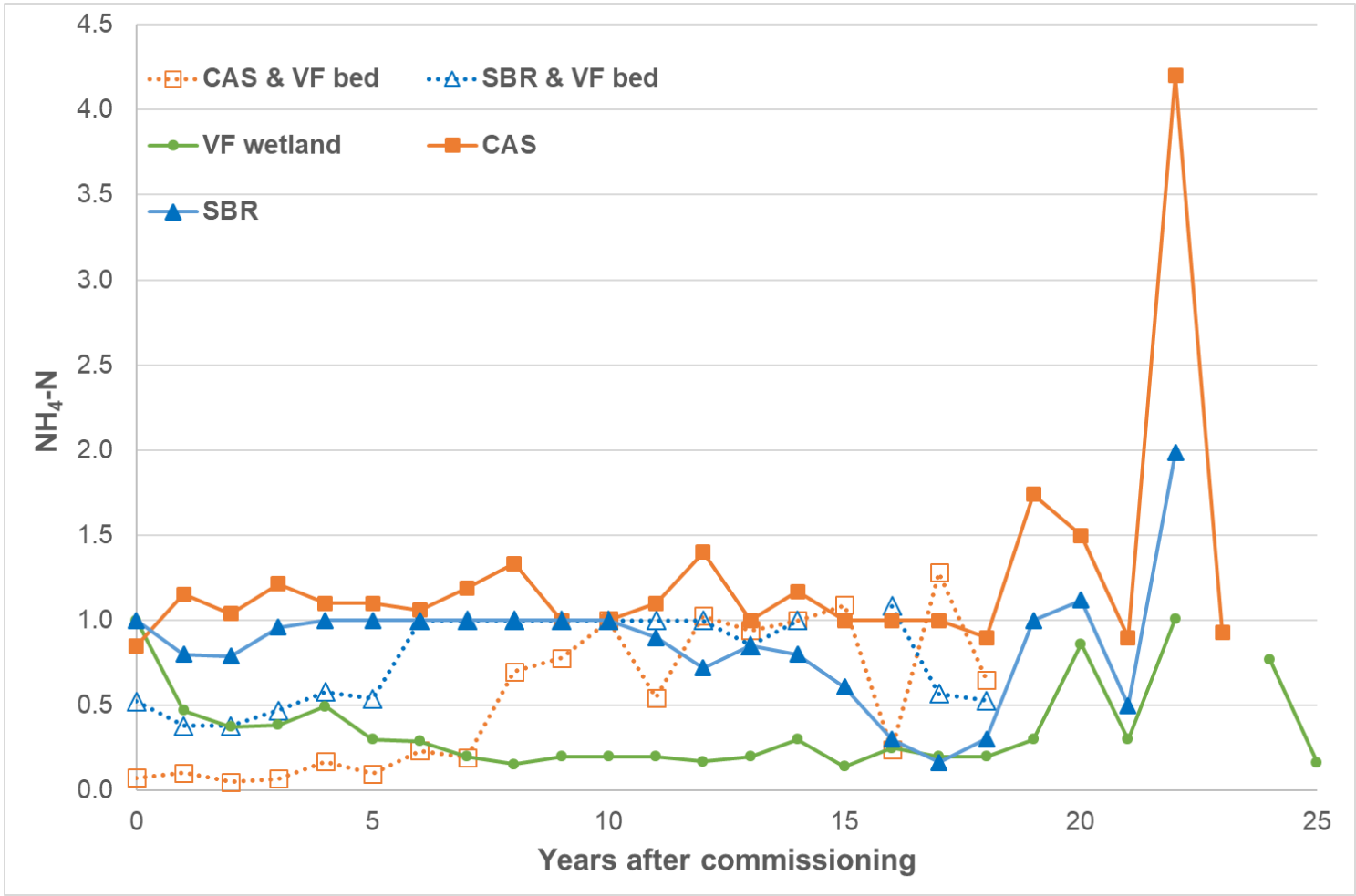




# Performance of small WWTPs < 50 PE

## Performance related to the age of the plant





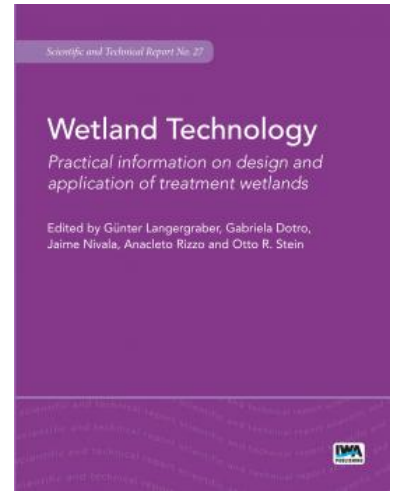
# Conclusions

- Local communities have to be able to operate the systems
  - ⇒ Technologies that are simple and robust and that have low O&M requirements and costs
  - ⇒ Natural solutions such as treatment wetlands are suitable
- There is a prejudice that treatment wetlands are less effective compared to technical solutions (such as activated sludge)
  - ⇒ Experience shows that treatment wetlands – if properly designed, constructed & operated – can achieve the same (if not better) treatment level as technical solutions
- For any small WWTP – also for natural solutions – proper operation, monitoring and maintenance is a key factor for well functioning
- Additionally, resources-oriented solutions facilitate well functioning of systems

# More on treatment wetlands …

**"Treatment Wetlands"**
http://wio.iwaponline.com/content/16/9781780408774
*Biological Wastewater Treatment Series, Volume 7, Open Access textbook*, IWA Publishing, London, UK, 172p.
ISBN: 9781780408774 (ebook).
Authors: Dotro, G., Langergraber, G., Molle, P., Nivala, J., Puigagut, J., Stein, O.R., von Sperling, M.


**"Wetland Technology: Practical information on the design and application of treatment wetlands"**
https://www.iwapublishing.com/books/9781789060164/wetland-technology-practical-information-design-and-application-treatment
*IWA Scientific and Technical Report No.*27, IWA Publishing, London, UK, 190p.
ISBN13: 9781789060164; ISBN: 9781789060171 (eBook).
Editors: Langergraber, G., Dotro, G., Nivala, J., Rizzo, A. , Stein, O.R.



150 JAHRE
NACHHALTIG
VORAUSSCHAUEN
1872 – 2022

UNIVERSITÄT FÜR BODENKULTUR WIEN

**Contact**

# Dr Günter 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 47654-81111
Email: guenter.langergraber@boku.ac.at