

Interreg
Danube Region



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Greening the Danube Region

Nature-based Solutions for **Wastewater** and Stormwater Management in Small Settlements

Webinar

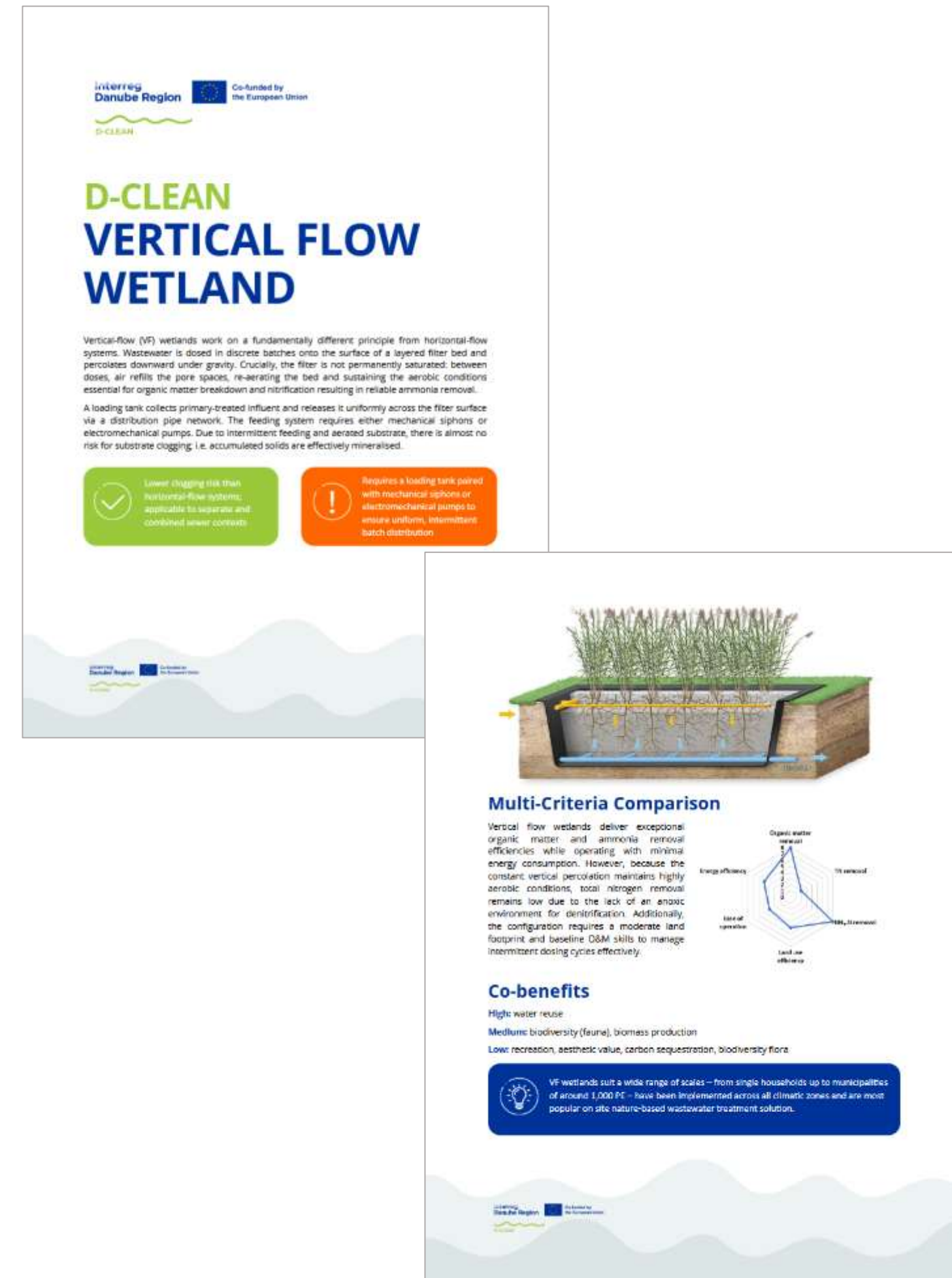
19 October 2026, 13:30 – 15:00 (CET)

Presenter

Alba Canet Martí, Dr.

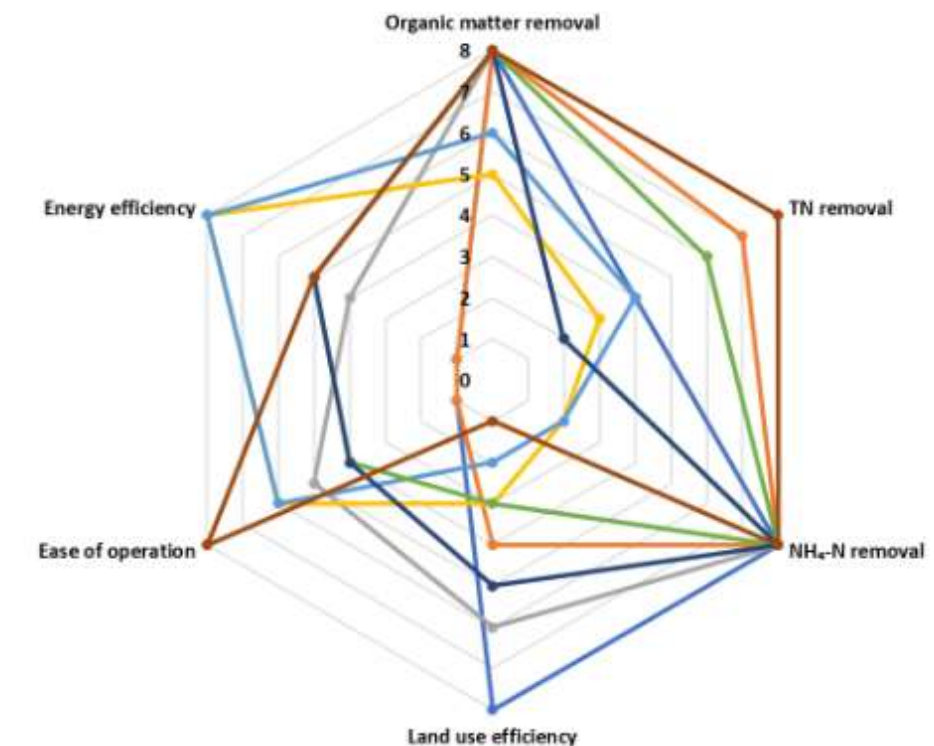
Knowledge Transfer & Training

- **FACTSHEETS** - Catalogue of potential stormwater and wastewater solutions for the Danube Region (D.1.4.1)
 - 8 NbS for wastewater treatment
 - 7 NbS for stormwater management
 - English + 6 local languages (HR, SI, HR, RS, HU, SK)
- **TEXTBOOK** – Nature-based solutions for WW and SW management (D.2.1.1)
 - Practical guidance for understanding, planning, and implementing NbS
 - General description
 - Design principles
 - Operational guidelines
 - Maintenance practices
 - Environmental considerations
 - English + 6 local languages (HR, SI, HR, RS, HU, SK)



NbS for wastewater treatment

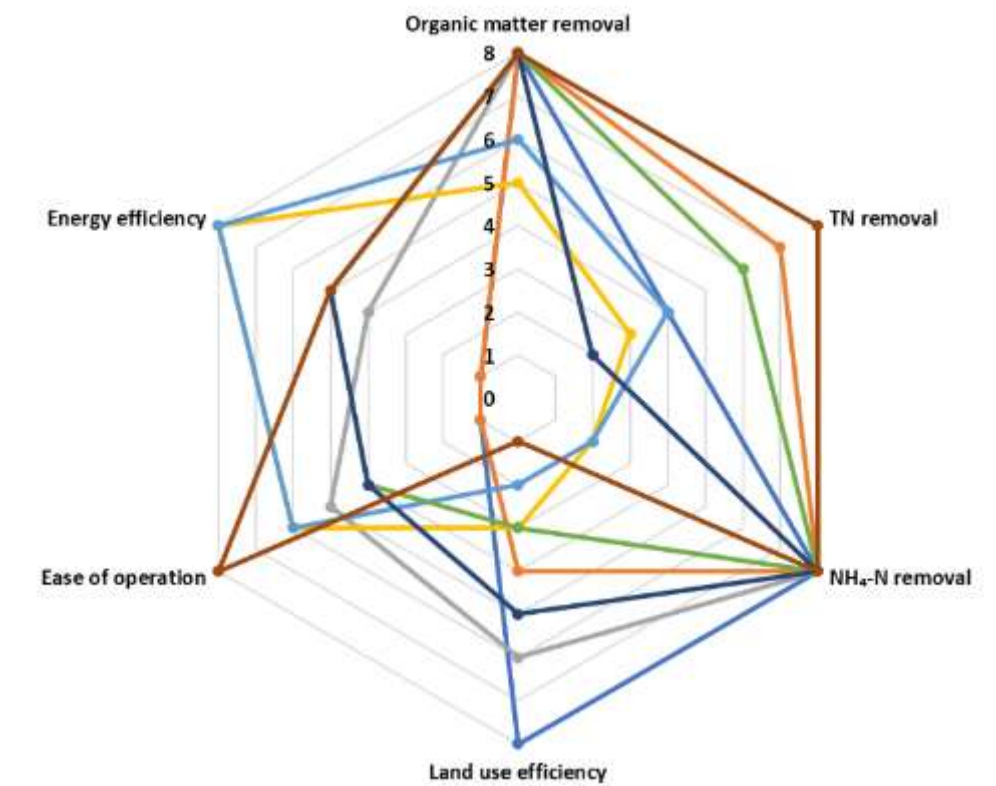
- NbS remove pollutants through a combination of physical, chemical, and **biological processes, with microbial activity playing a key role**
- **System design and operation** create different conditions (aerobic, anoxic...), each favoring specific removal processes
- **Combining NbS types** targets a wider range of pollutants
- **Ideal for small settlements**: scalable from single households to ~1,000 – 2,000 PE, adaptable to different climates



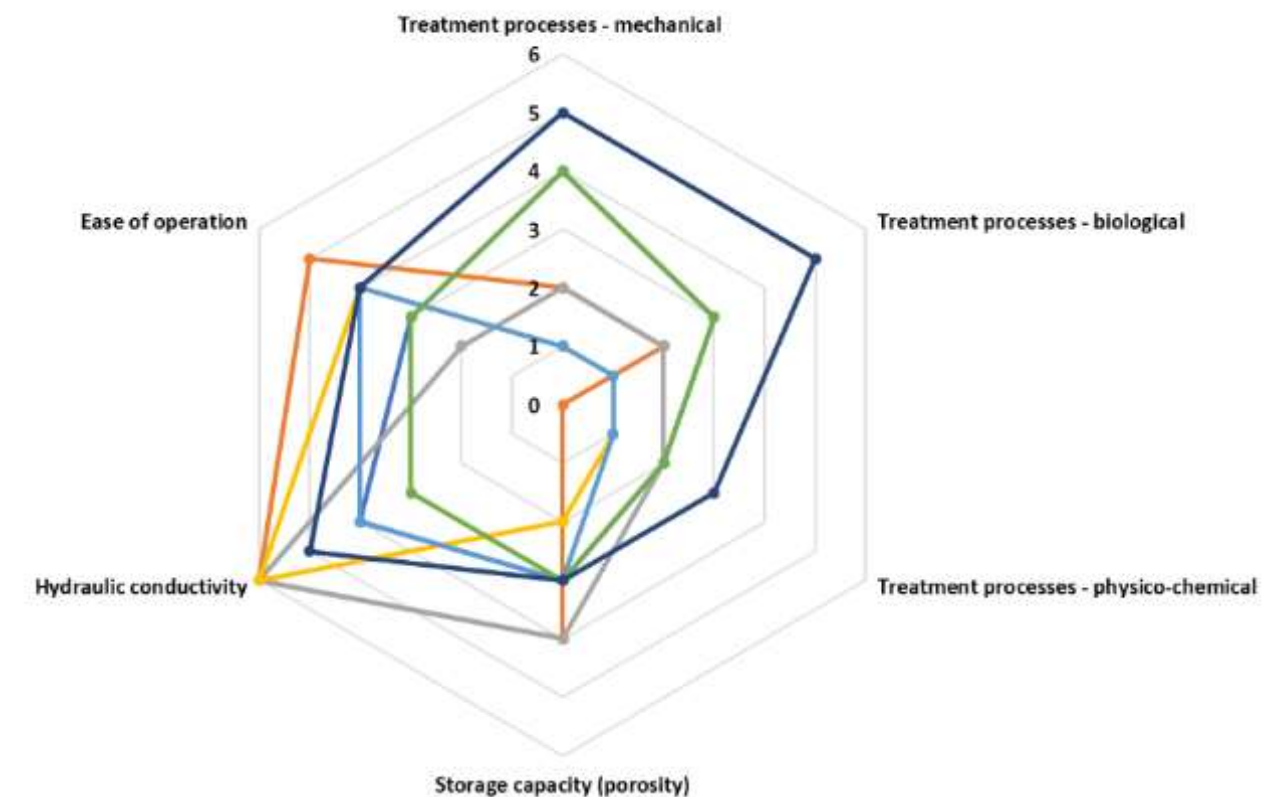
Multi-criteria comparison

- **Preliminary assessment:** relative comparison of NbS across key criteria for wastewater and stormwater
- **Radar plots:** indicative scores for quick comparison, not absolute values
- **Expert-based scores** drawn from scientific literature, practical experience and partner expertise
- **No single best NbS:** each balances treatment performance against land, skills and energy needs

Criteria for Wastewater NbS



Criteria for Stormwater NbS



D-CLEAN VERTICAL FLOW WETLAND

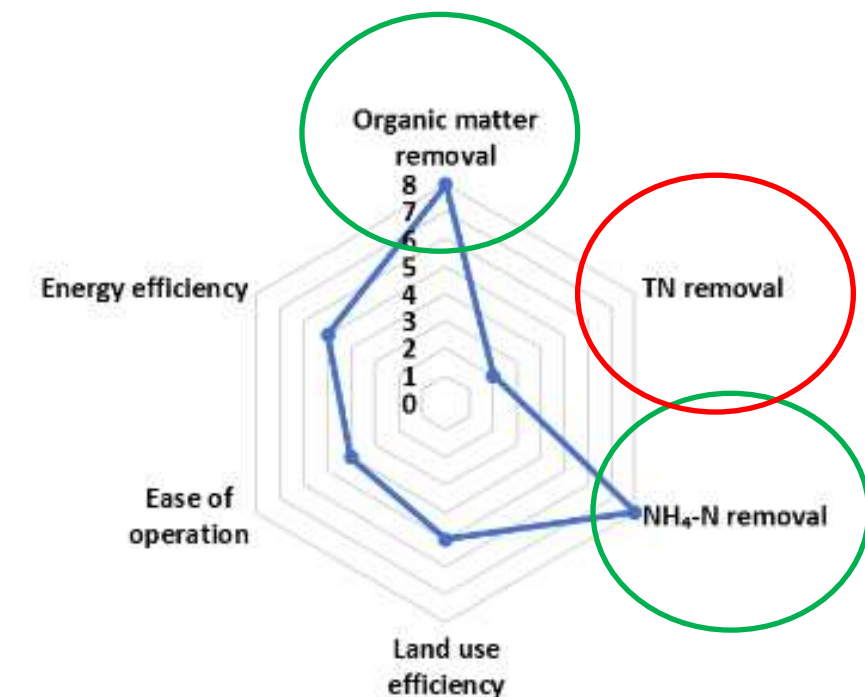
- **Vertical percolation** through the filter bed
- **Intermittent feeding** re-aerates the bed and keeps aerobic conditions
- **Organic matter degradation and nitrification** (ammonia removal)



Lower clogging risk than horizontal-flow systems; applicable to separate and combined sewer contexts



Requires a loading tank paired with mechanical siphons or electromechanical pumps to ensure uniform, intermittent batch distribution



Co-benefits

High: water reuse

Medium: biodiversity (fauna), biomass production

D-CLEAN HORIZONTAL FLOW WETLAND

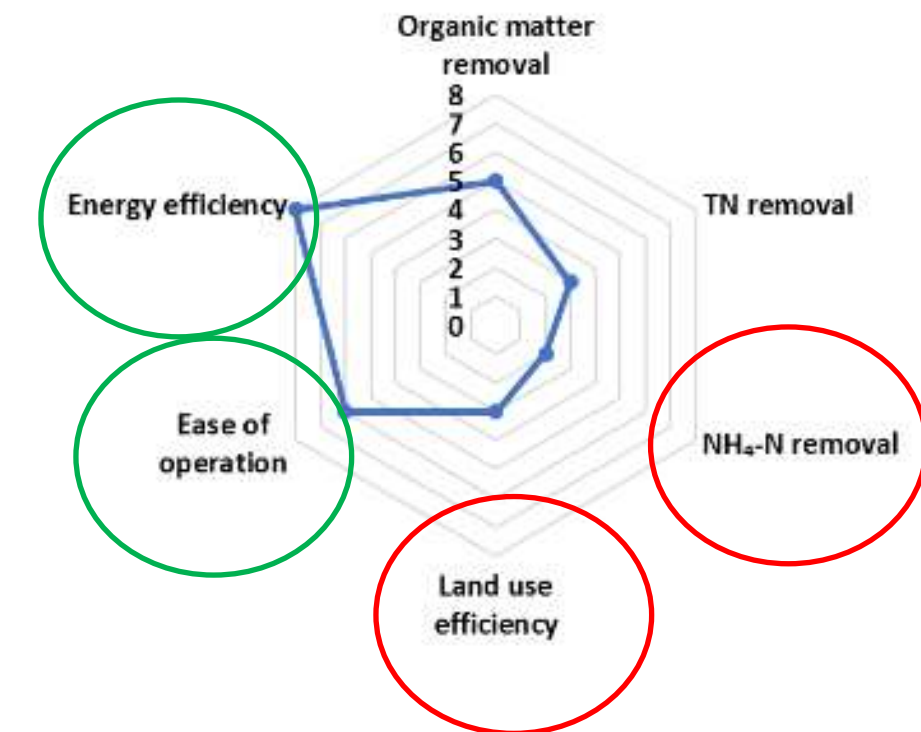
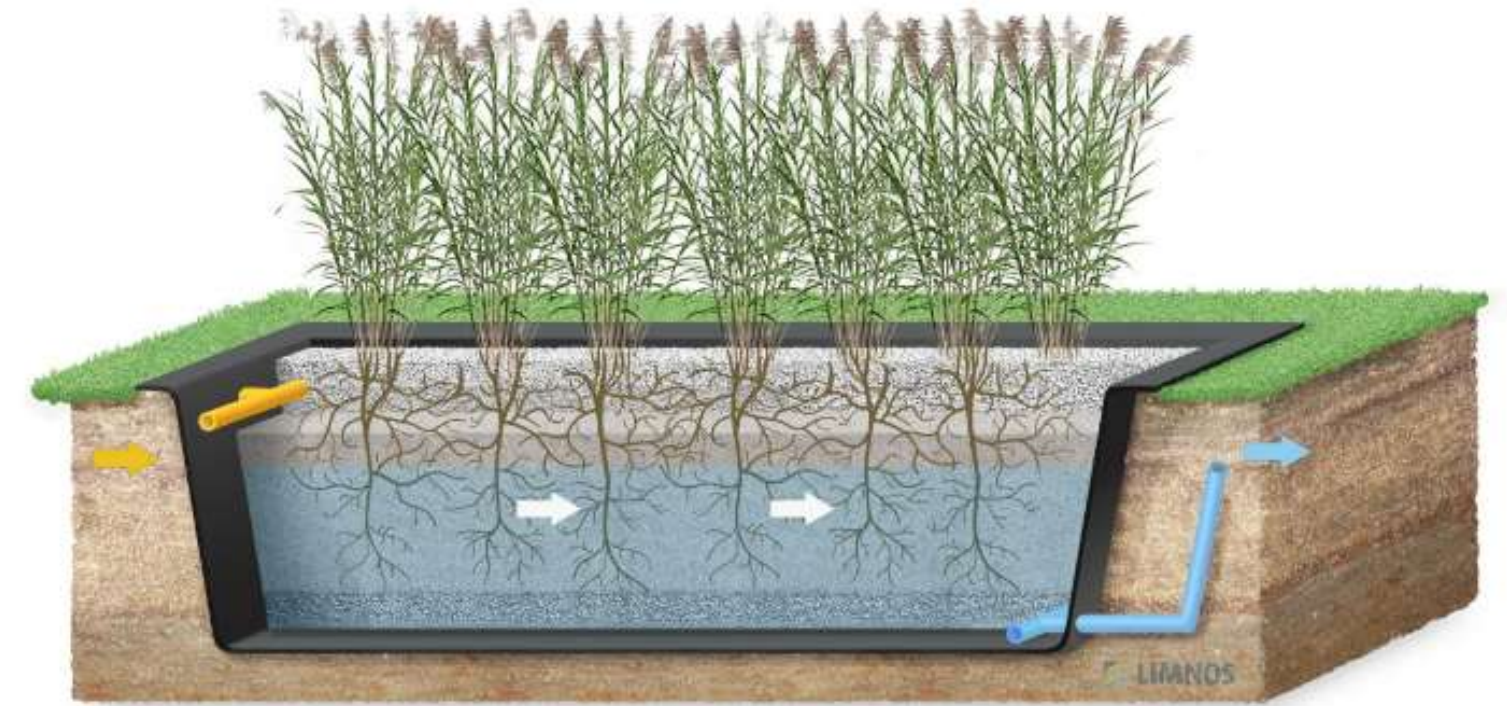
- **Continuous feeding** distributed across the bed width
- **Fully saturated bed** creates anoxic conditions that favour denitrification
- **Combined** with other type of treatment wetlands to improve total nitrogen removal



Consistent treatment performance while effectively buffering variable inflows with minimal energy requirements



Larger land requirement and limited passive oxygen transfer



Co-benefits

High: water reuse

Medium: biodiversity (fauna), biomass production

D-CLEAN FRENCH VERTICAL- FLOW WETLAND

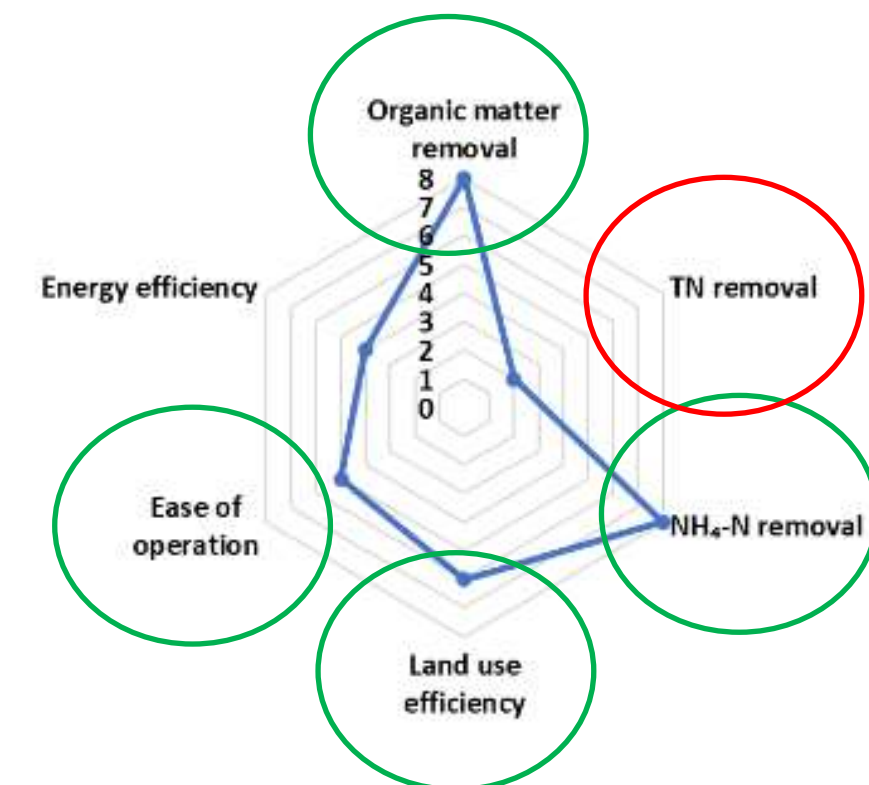
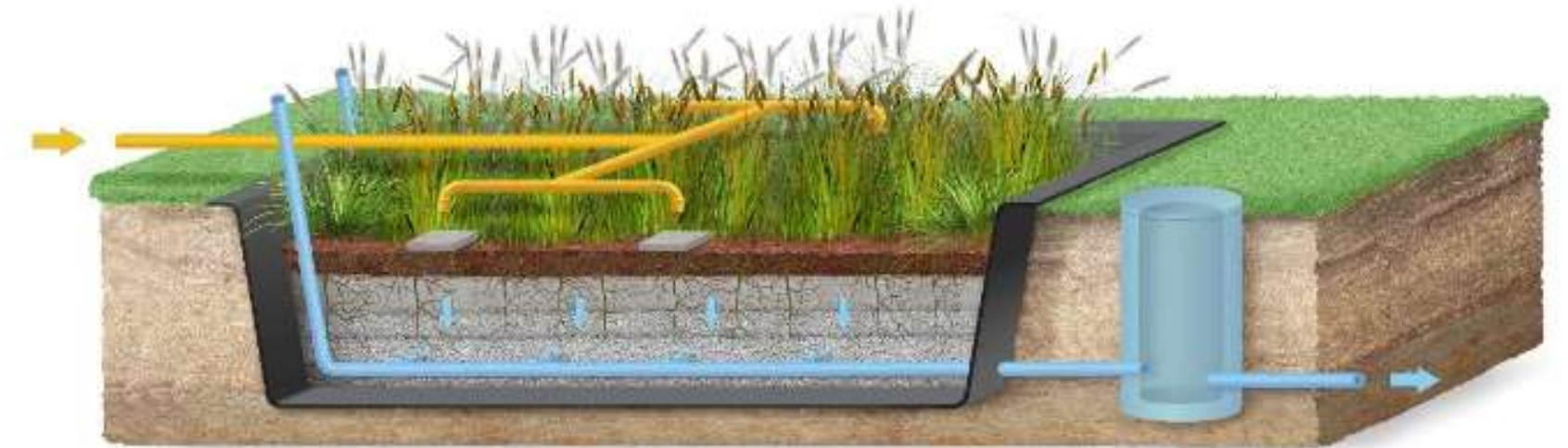
- **Two-stage system** with beds operated alternately (typically three VF beds in stage 1 and two in stage 2)
- **Raw wastewater fed directly**, with sludge treated in situ on the 2st-stage beds
- **Adaptable 2nd stage** to meet effluent targets (e.g., VF with saturation layer or HF for nitrification)



Eliminates primary settling tanks, reducing the initial footprint and simplifying overall operations; produces stabilised sludge for nutrient reuse



Mechanical (siphons) or electromechanical (pumps) components to ensure intermittent batch dosing



Co-benefits

High: water reuse, biosolids

Medium: biodiversity (fauna), biomass production

D-CLEAN WILLOW SYSTEMS

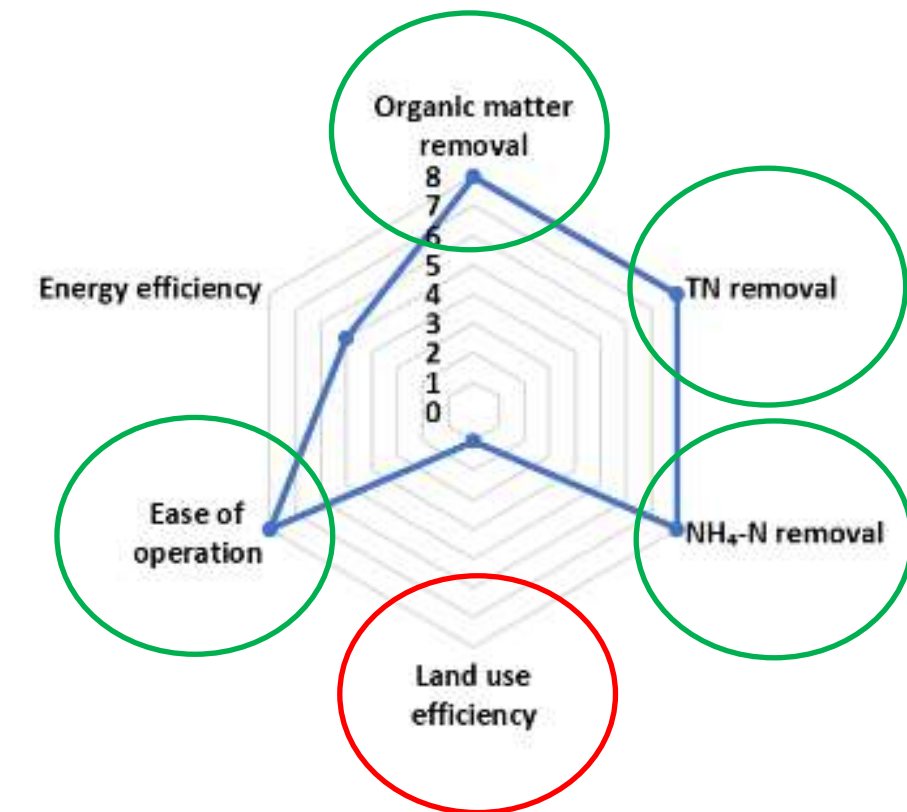
- **Zero-discharge systems** planted with fast-growing willows
- **Evapotranspiration** removes all water, so there is no outflow
- **Nutrients and pollutants** retained in soil and biomass, then removed by harvesting



Zero emissions to the environment; high yields of harvestable woody biomass



Biomass harvesting is mandatory; sizing depends on local evapotranspiration and is sensitive to climate



Co-benefits

High: pollination, biomass production, carbon sequestration

Medium: biodiversity (fauna and flora), aesthetic value, recreation

D-CLEAN AERATED WETLAND

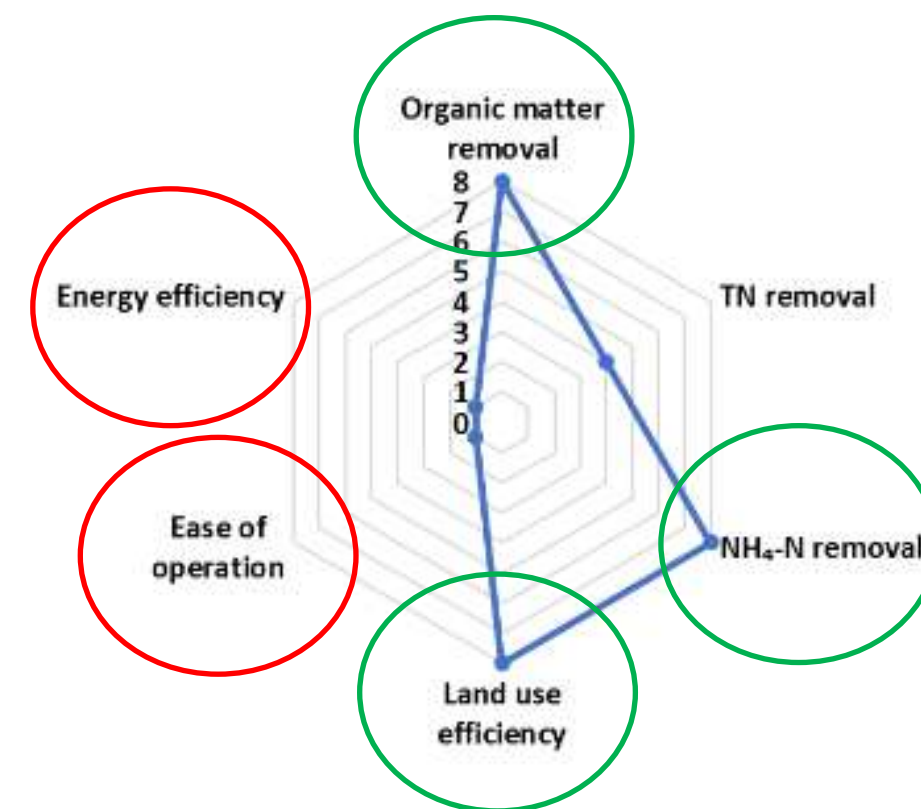
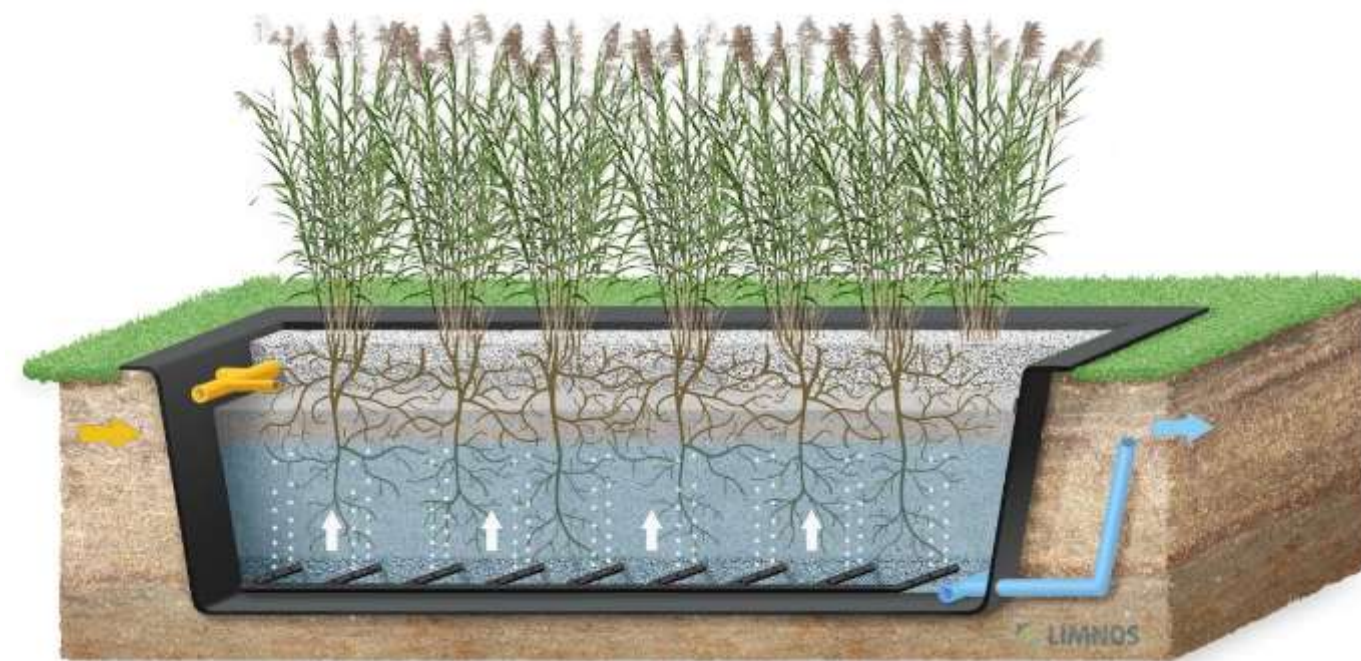
- **Intensified treatment wetlands:** saturated HF or VF beds with active aeration
- **Added oxygen** boosts aerobic processes (OM degradation, nitrification)
- **Intermittent aeration** alternates aerobic and anoxic conditions for total nitrogen removal



Lower land requirement due to enhanced treatment efficiency compared to other treatment wetlands



Increased system complexity and energy requirements for aeration, leading to additional mechanical equipment and higher maintenance demands



Co-benefits

High: water reuse

Medium: biomass production

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D-CLEAN AERATED + FREE WATER SURFACE WETLAND

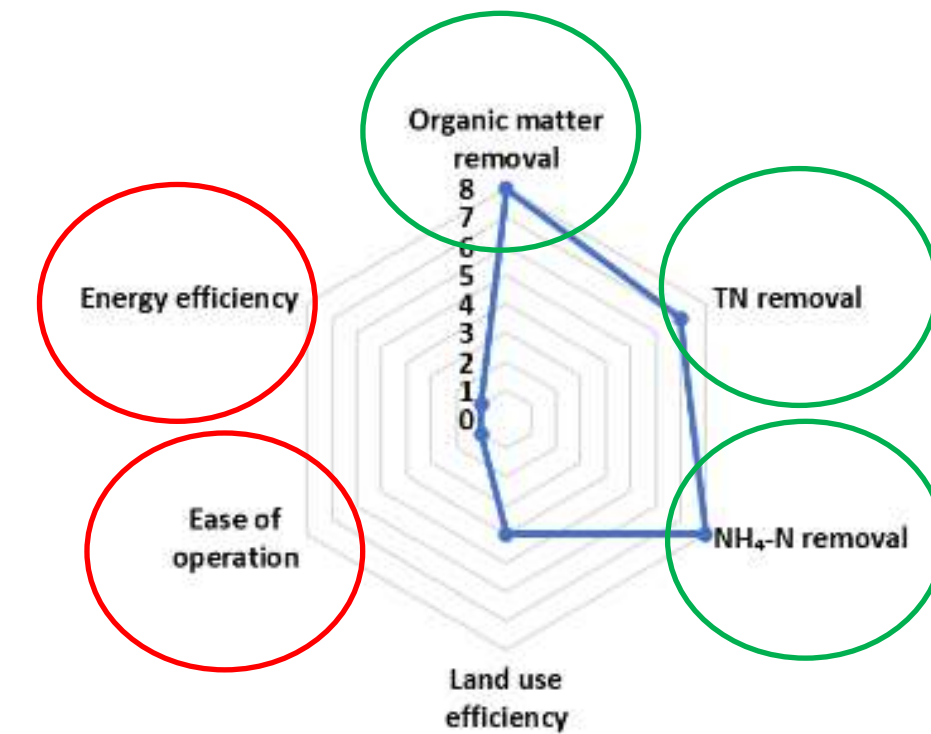
- **Aerated wetland benefits + natural polishing** in a FWS wetland (3rd stage)
- **Resilient** to load fluctuations
- **Total nitrogen removal** in the anoxic bottom zone of the FWS wetland



Highly resilient to load fluctuations due to the complementary behaviour of both stages



Increased system complexity and energy requirements for aeration, as well as seasonal variability in treatment performance due to the temperature sensitivity of the FWS wetland



Co-benefits

High: CSO mitigation/storm peak mitigation, water reuse

Medium: biodiversity (fauna and flora), carbon sequestration, biomass production

D-CLEAN VERTICAL FLOW AND HORIZONTAL FLOW WETLAND

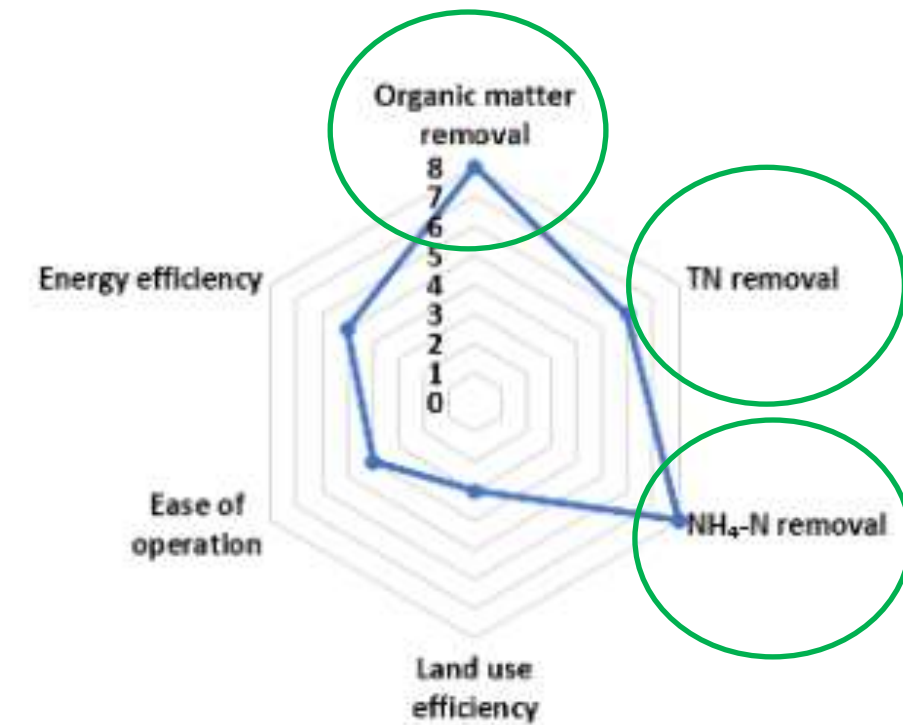
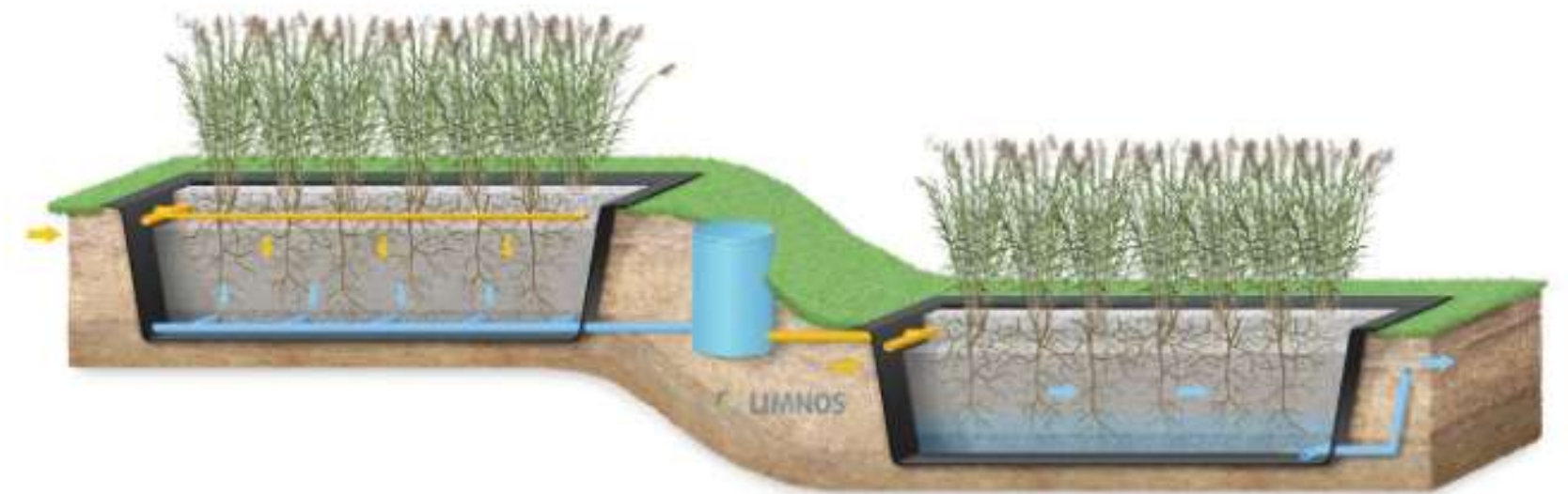
- **Combined system** with complementary conditions for enhanced nitrogen removal
- **VF wetland**: aerobic conditions favour **nitrification**
- **HF wetland**: anoxic conditions favour **denitrification**



Full nitrogen cycle achievable in a compact footprint; gravity-fed operation is possible



Each stage requires expert design; denitrification performance is constrained by carbon availability



Co-benefits

High: water reuse

Medium: biodiversity (fauna), biomass production

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D-CLEAN HORIZONTAL FLOW + FREE WATER SURFACE WETLAND



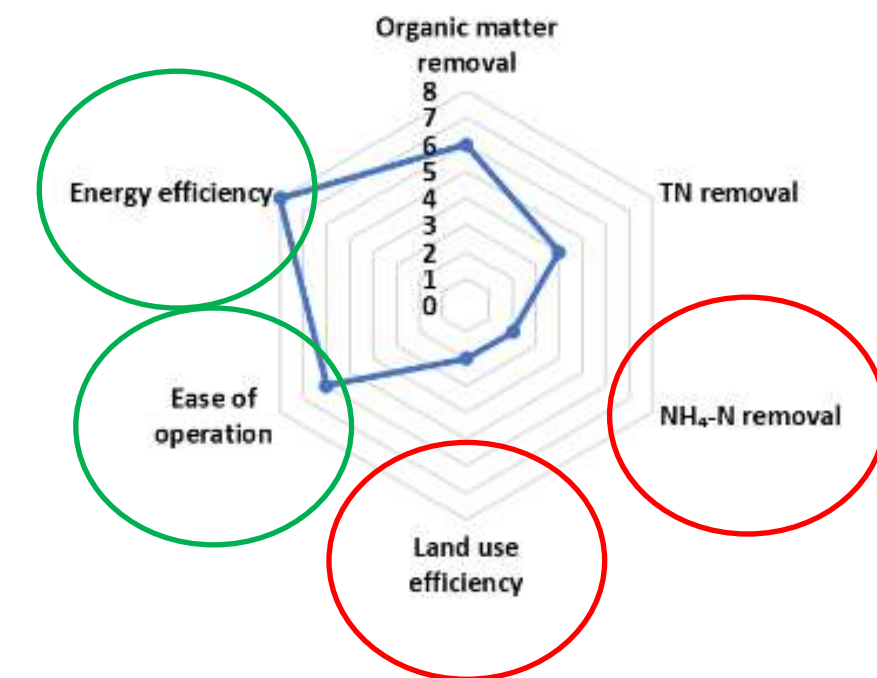
- **Combined system** with complementary conditions for enhanced pollutant removal
- **HF wetland:** anoxic conditions favour denitrification
- **FWS wetland for polishing:** upper column aerobic + bottom zone anoxic, plus nutrient uptake and P retention



Natural UV disinfection and aerobic polishing provide high-quality effluent



Potential seasonal sensitivity of the open surface pond.



Co-benefits

High: water reuse

Medium: biodiversity (fauna), biomass production

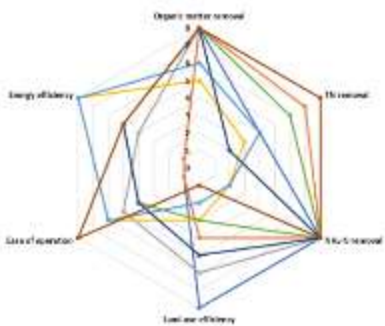
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Multi-criteria comparison



OM removal

AERATED WETLAND
AERATED + FREE WATER SURFACE WETLAND
VERTICAL FLOW WETLAND
WILLOW SYSTEMS
FRENCH VERTICAL-FLOW WETLAND
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TN Removal

WILLOW SYSTEMS
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NH₄-N Removal

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Land use efficiency

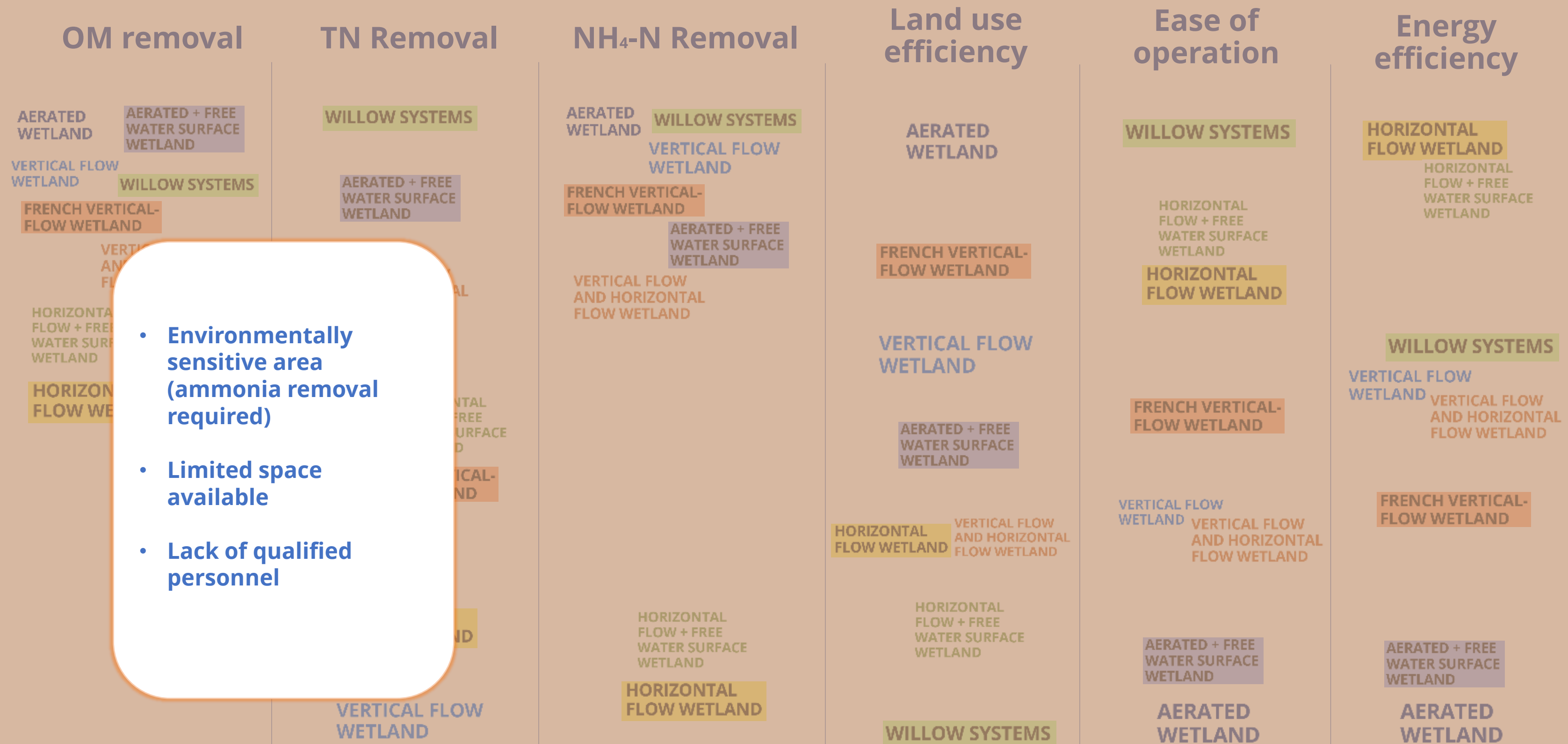
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WILLOW SYSTEMS

Ease of operation

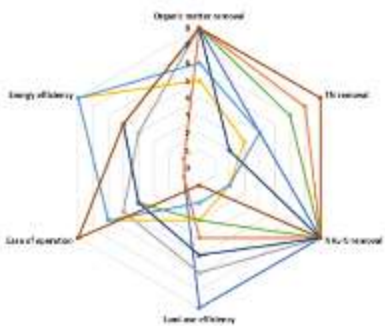
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HORIZONTAL FLOW WETLAND

- Environmentally sensitive area (ammonia removal required)
- Limited space available
- Lack of qualified personnel

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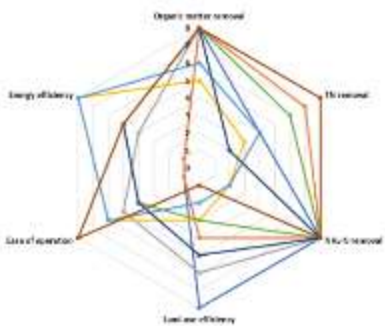
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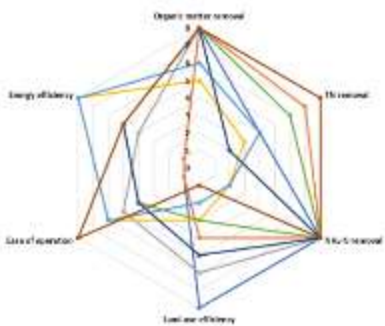
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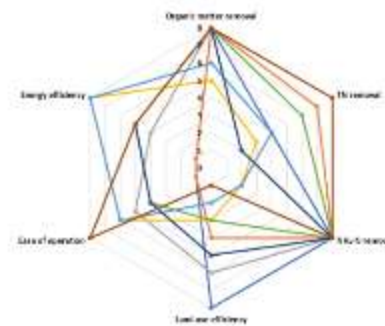
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- **Space is not a constraint**
- Lack of qualified personnel

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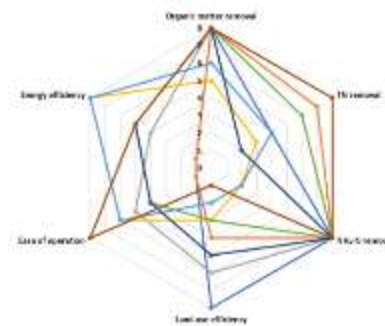
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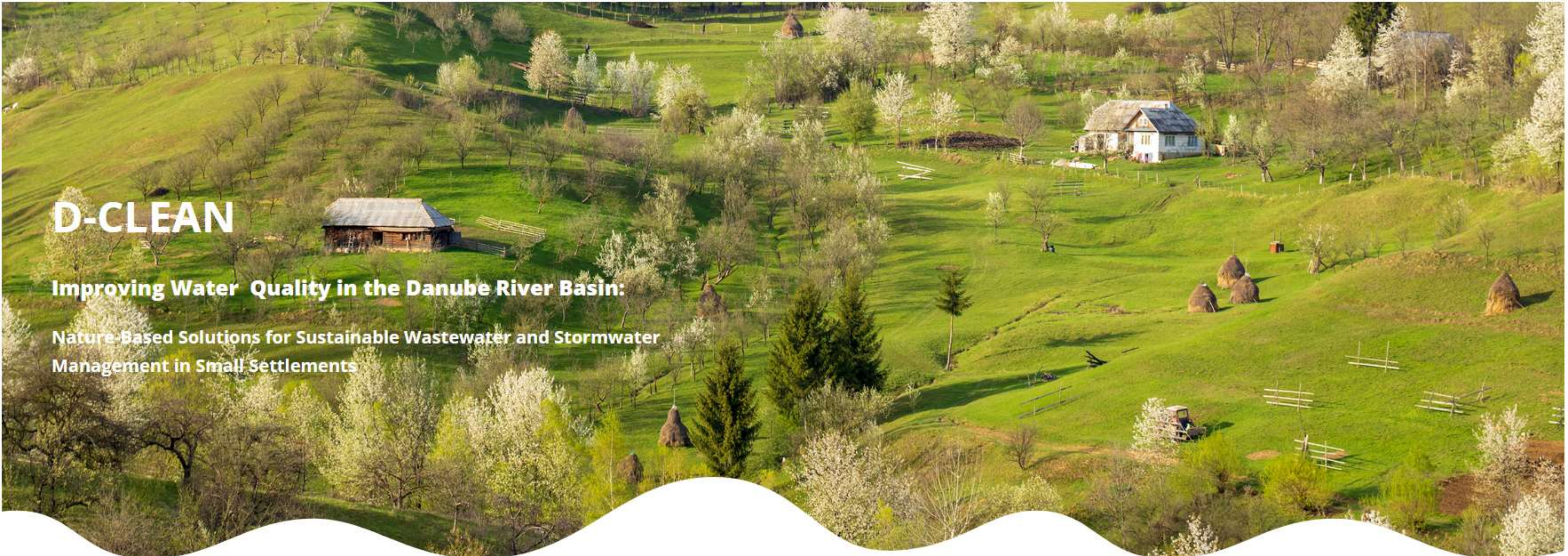
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D-CLEAN

Improving Water Quality in the Danube River Basin:

**Nature-Based Solutions for Sustainable Wastewater and Stormwater
Management in Small Settlements**

**Thank you for
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<https://interreg-danube.eu/projects/d-clean>

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