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Wetlands for Water Management
CWA Annual Conference and AGM

26 – 27th June, Cardiff University, Wales

UNIVERSITÀ DEGLI STUDI DI TRENTO

The use of aeration in VSSF to reduce land area requirements in CWs

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June 2013

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- Aerated VSSF – methods
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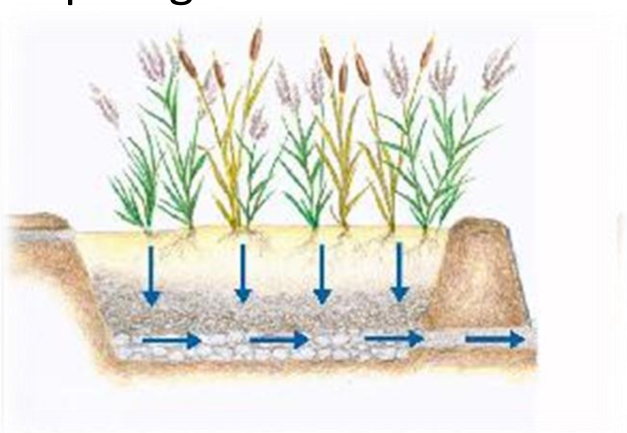
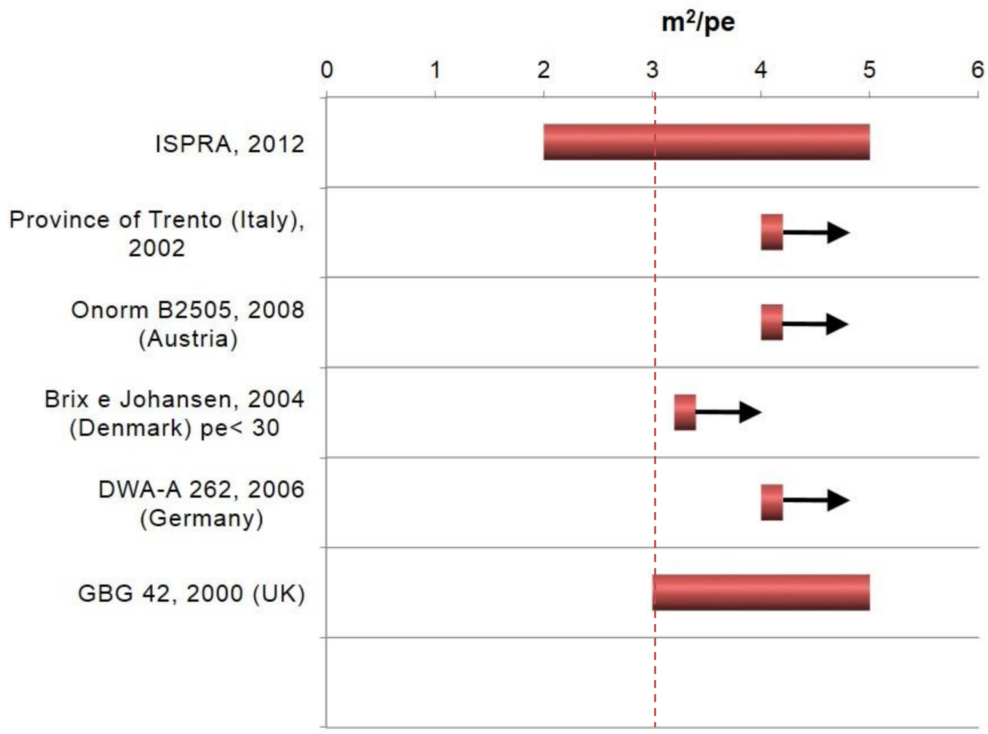
Introduction

Constructed wetlands (CW) are known for low costs, sustainability and efficiency in the treatment of municipal wastewater.

The LAND AREA REQUIREMENT is the main barrier for the application in tourist villages and small agglomerations in the Alps region.





Vertical Sub-Surface Flow (VSSF) CWs

Introduction

- Some efforts have been made in literature to improve the conventional CW with the aim to reduce land area requirements and enhance nitrification and nitrogen removal.

Among some techniques utilized:

-alternate feeding periods

-recirculation of the treated wastewater

-

- artificial aeration in HSSF

(conventionally oxygen-limited systems).

Objectives

- The aim of this research was to apply innovative configurations in the VSSF to reduce land area requirements and enhance nitrification and nitrogen removal.

✓Intermittent artificial aeration in the saturated layer.

For the reduction of land area higher hydraulic and organic loads were applied.

Innovative high load configuration was compared with a conventional CW configuration.

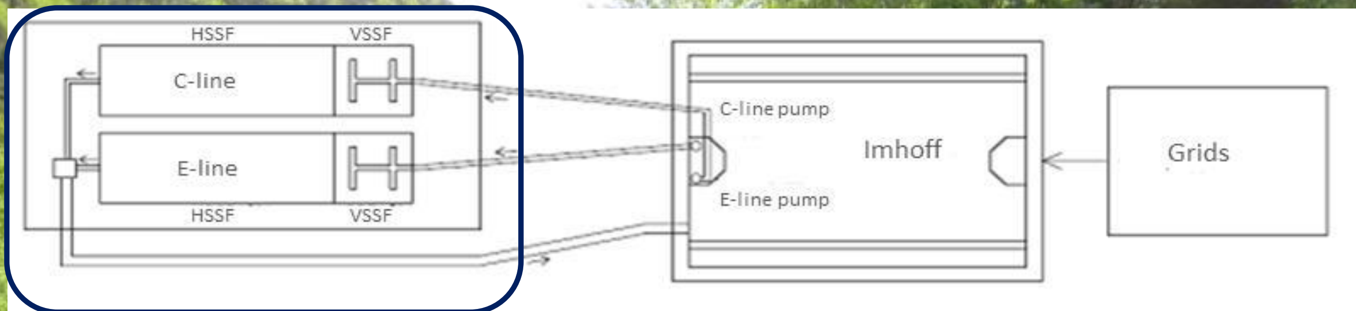
Methods

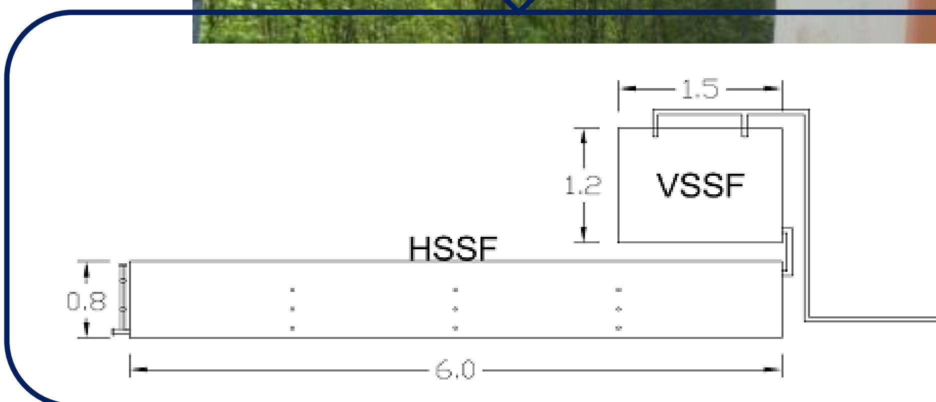
Ranzo
Province of Trento
Italy

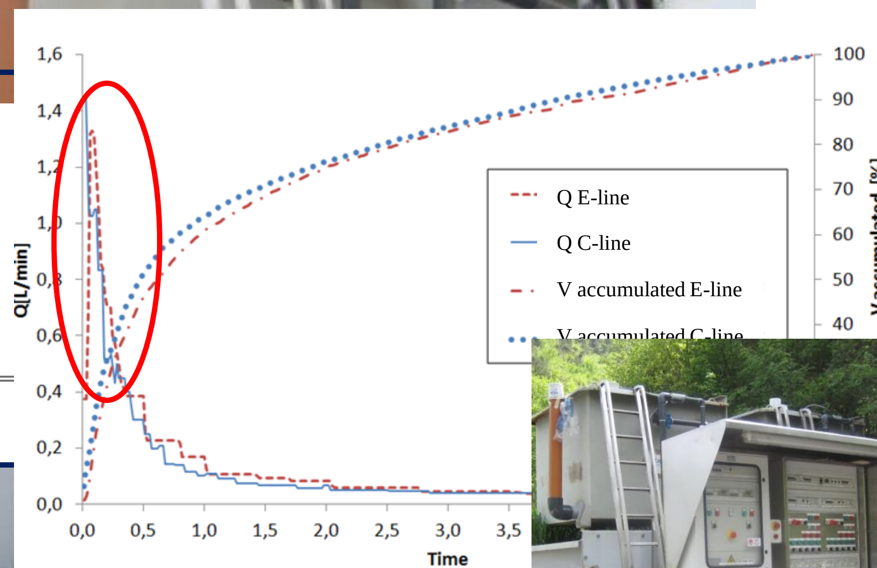
Location: Alps region
Elevation: 739 m a.s.l.

Pilot Plant

Pilot plant

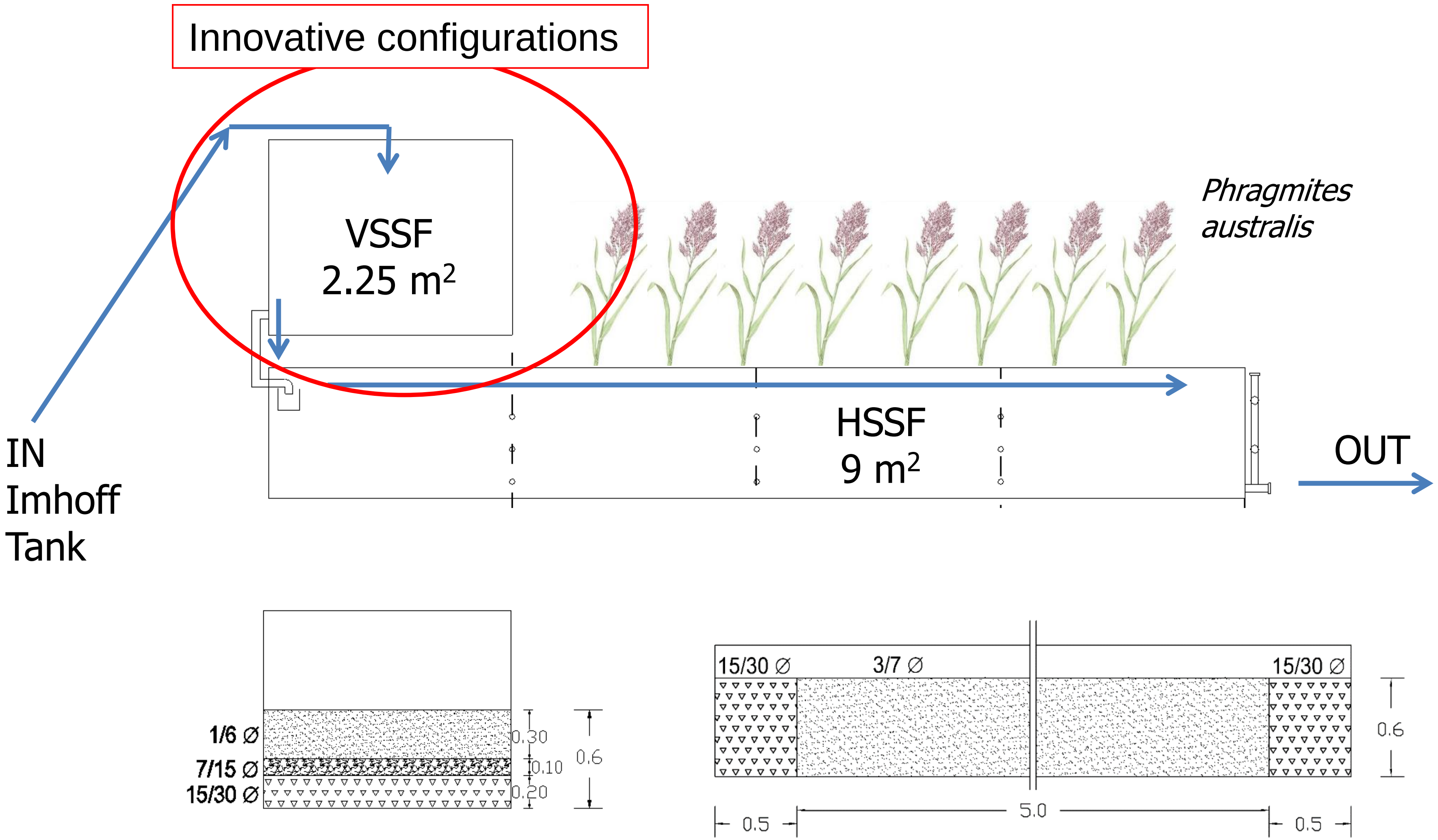






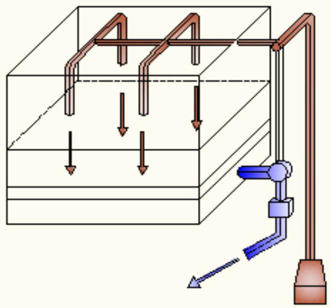
Inlet/outlet samples and Track studies:
COD, COD solubile, TSS, NH_4-N, NO_3-N, NO_2-N, TKN, Total P, P-PO_4^{3-} (APHA, 2005)

Methods


Innovative configurations
VSSF
2.25 m²
Phragmites australis
HSSF
9 m²
IN
Imhoff
Tank
OUT
1/6 Ø
7/15 Ø
15/30 Ø
0.30
0.10
0.20
0.6
15/30 Ø
3/7 Ø
15/30 Ø
0.6
0.5
5.0
0.5

Methods

Configurations tested

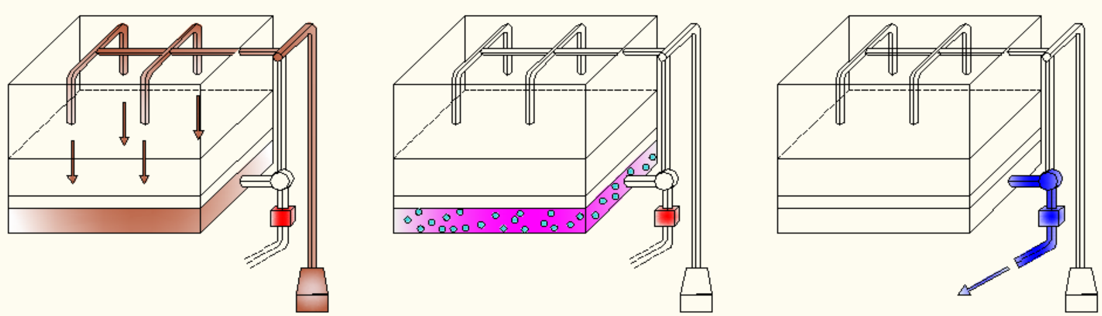


FEEDING AND
FREE-DISCHARGE

Conventional down-flow configuration

→ 1) Low Load VSSF: 3.2 m^2/pe

FEEDING AERATION DISCHARGE



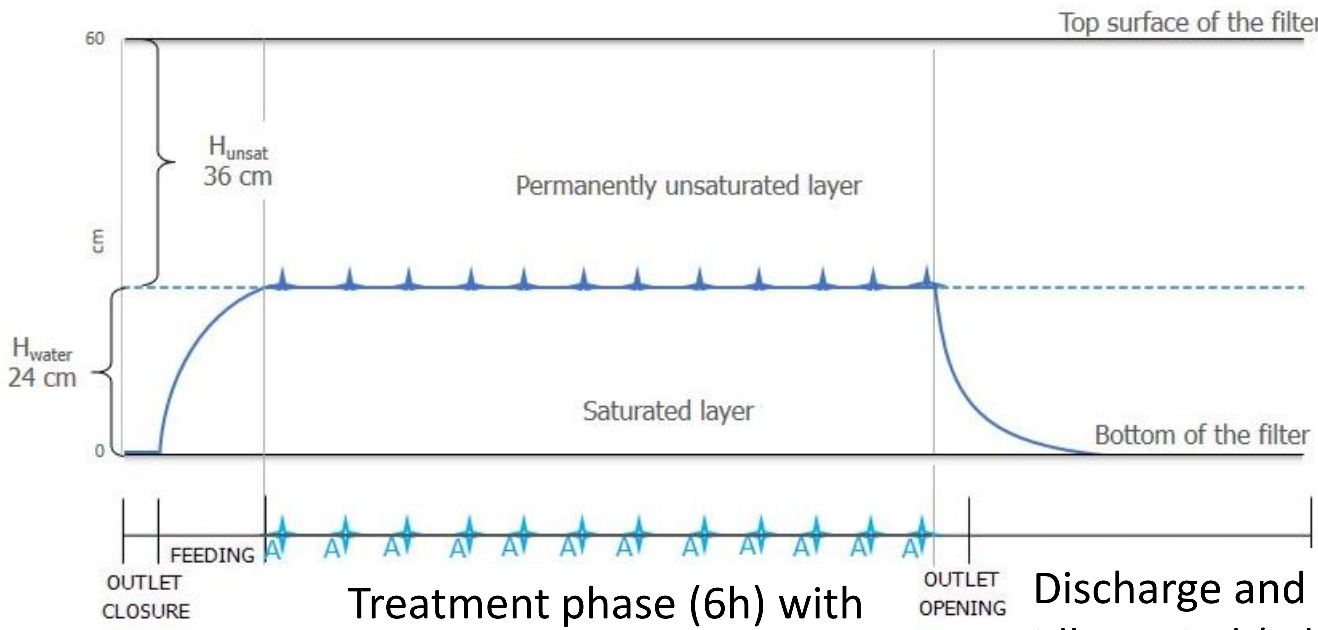
2) High Load Aerated VSSF: 1.9 m^2/pe

Aeration:
5 min every 30 min

Equipment: small air blower connected to perforated pipes on the bottom of the bed

Methods

Aerated VSSF: Fill and drain VSSF + intermittent aeration in the saturated layer.



Treatment phase (6h) with intermittent aeration (5 min every 30min)

Discharge and idle period (4 h) unsaturated conditions restored

12 Sampling points

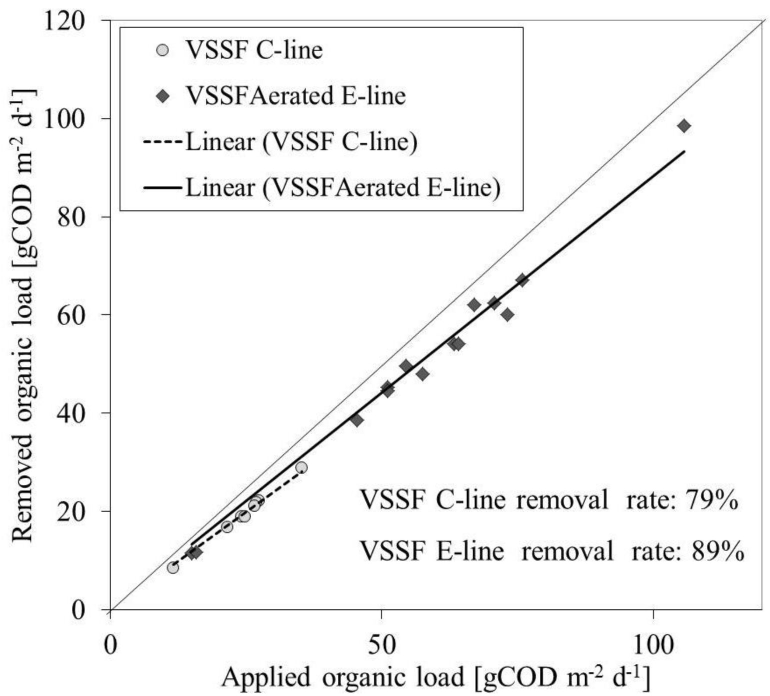
simultaneous nitrification /denitrification

Methods

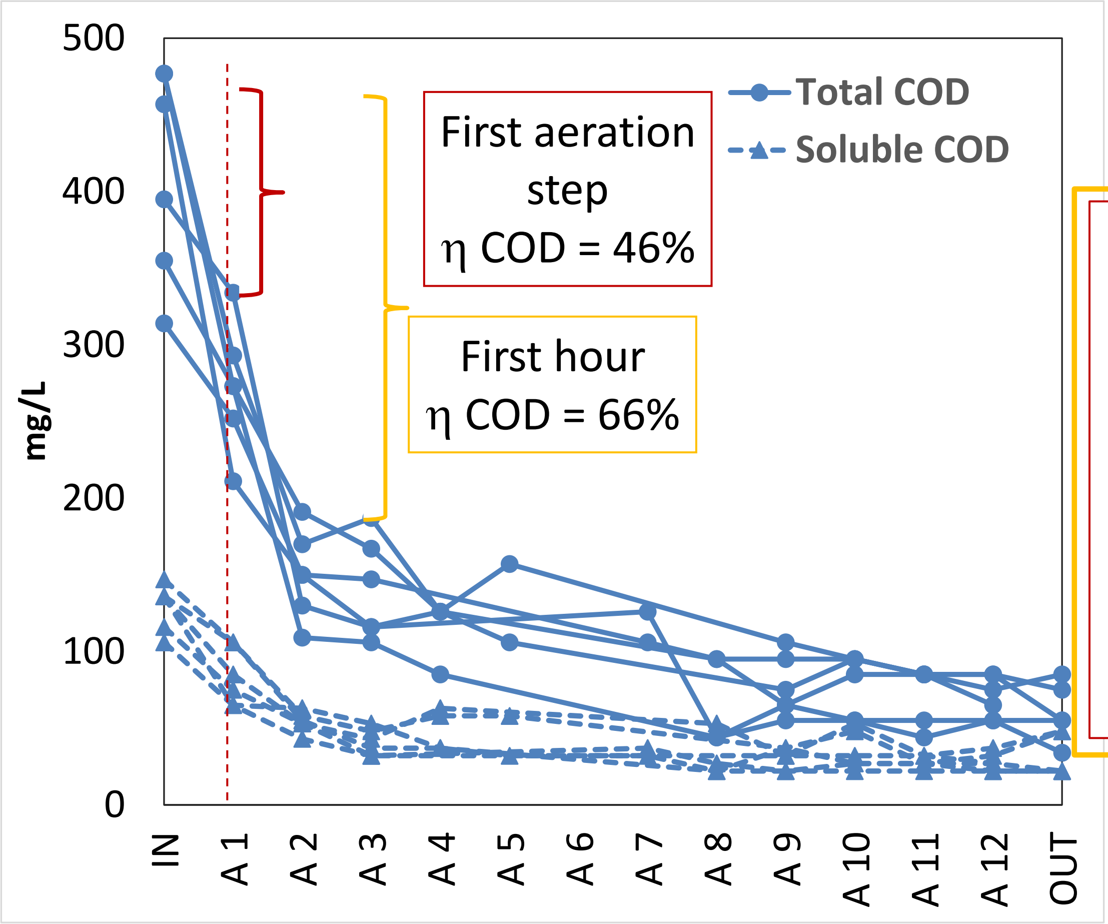
	Parameter	Units	Aerated VSSF	C-line
VSSF	Influent flow rate (hydraulic load)	L/d	304	149
	Specific hydraulic load	$L\ m^{-2}\ d^{-1}$	135	65
	Surface organic load	$gCODm^{-2}d^{-1}$	58	25
	Specific area	m^2/PE	1.9	4.2
	Cycles per day (feeds per day)	#/d	2.2	3.6
	Resting period (between feeds)	H	10.8	6.6
HSSF	Specific hydraulic load	$L\ m^{-2}\ d^{-1}$	34	16
	Specific area (all the bed= 9 m^2)	m^2/PE	8.7	19.5

Results

	Parameter	Aerated VSSF	C-Line
COD	Applied COD load in VSSF [gCOD m^{-2} d^{-1}]	57.6	24.8
	Removed COD load in VSSF [gCOD m^{-2} d^{-1}]	50.7	19.7



Results



First passage through the bed:

- Pore water dilution;
- Physical retention of particulated COD;
- Biological oxidation of biodegradable compounds

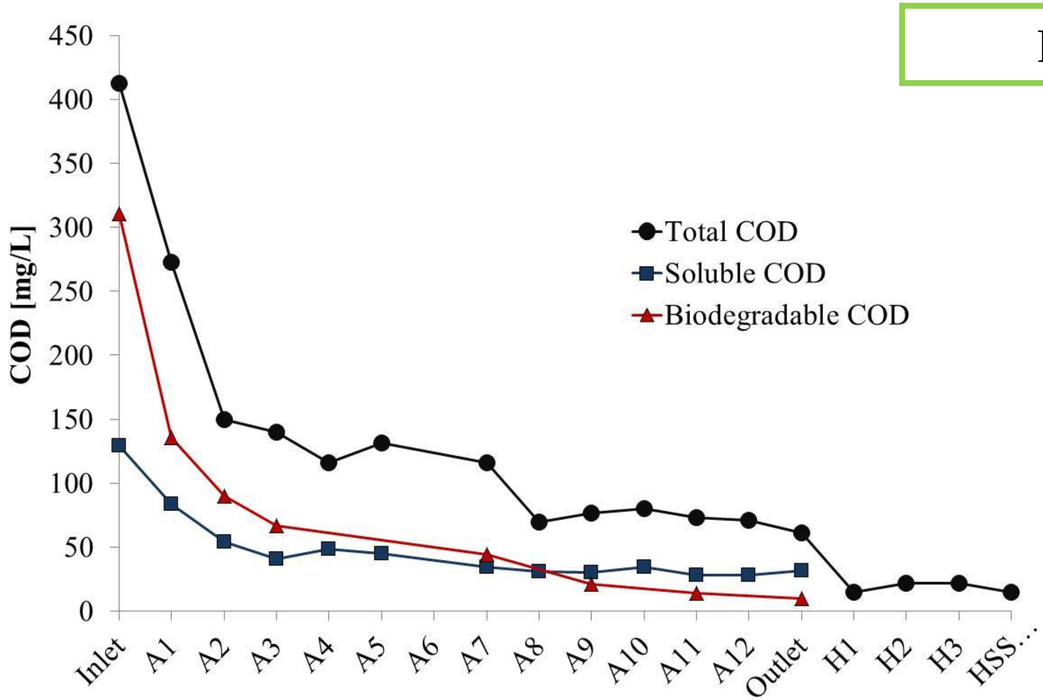
Time-profiles during the treatment phase in the A-VSSF: Total COD and sCOD. Legend: IN = influent wastewater; A1-A12 = intermittent aerations; OUT = effluent wastewater.

Results

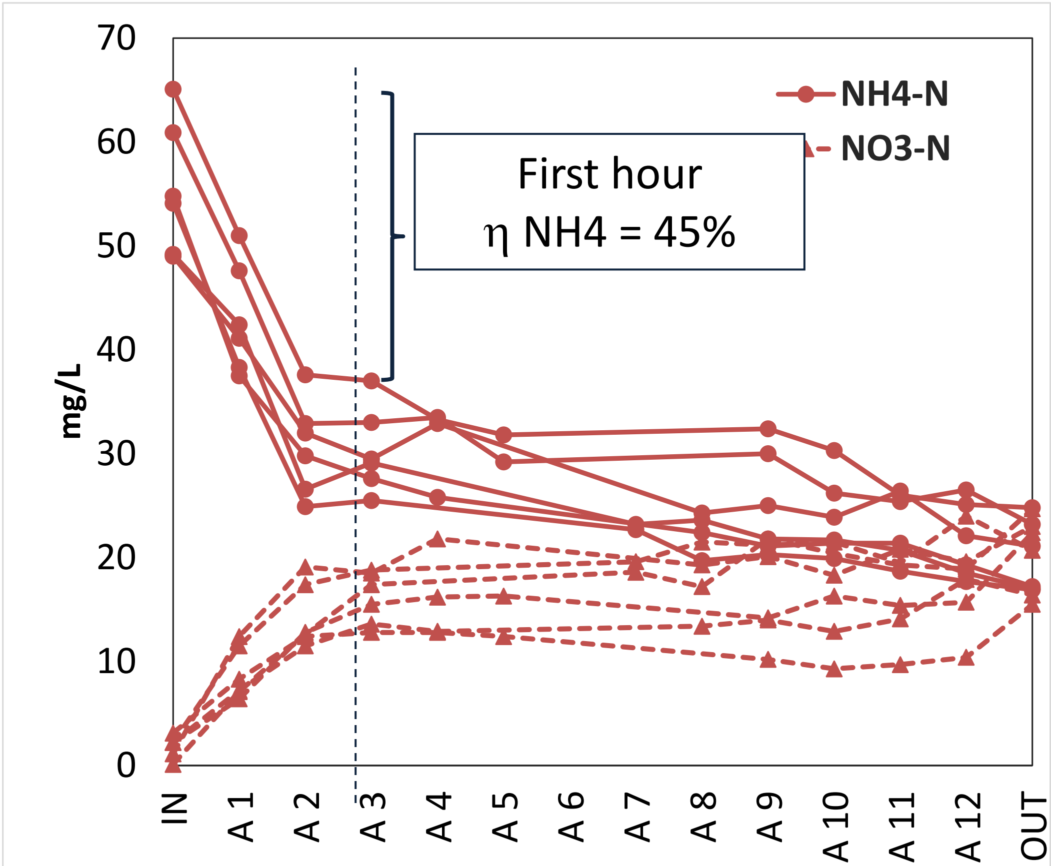
High removal efficiencies
→ Longer HRT

COD	Aerated VSSF	C-line
VSSF Efficiency	89%	79%
VSSF Effluent	52 mg/L	105 mg/L
VSSF+HSSF Efficiency	96%	92%
VSSF+HSSF Effluent	19 mg/L	23 mg/L

Polishing function



Results



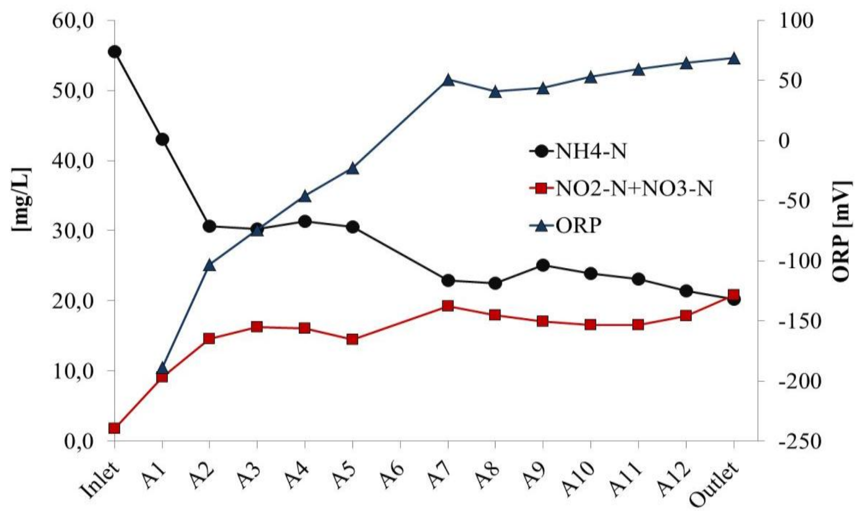
NH_4-N concentration in the bed not significantly reduced by intermittent aeration on the bottom.

Reasons: nitrifying bacteria less present or insufficient oxygen supplied by aeration.

Time-profiles during the treatment phase in the A-VSSF: NH_4-N and NO_3-N.
Legend: IN = influent wastewater; A1-A12 = intermittent aerations; OUT = effluent wastewater.

Results

NH_4-N	Aerated VSSF	C-line
VSSF Efficiency	69%	79%
VSSF Effluent	19.4 mg/L	13.2 mg/L
VSSF+HSSF Efficiency	93%	92%
VSSF+HSSF Effluent	5.7 mg/L	4.9 mg/L



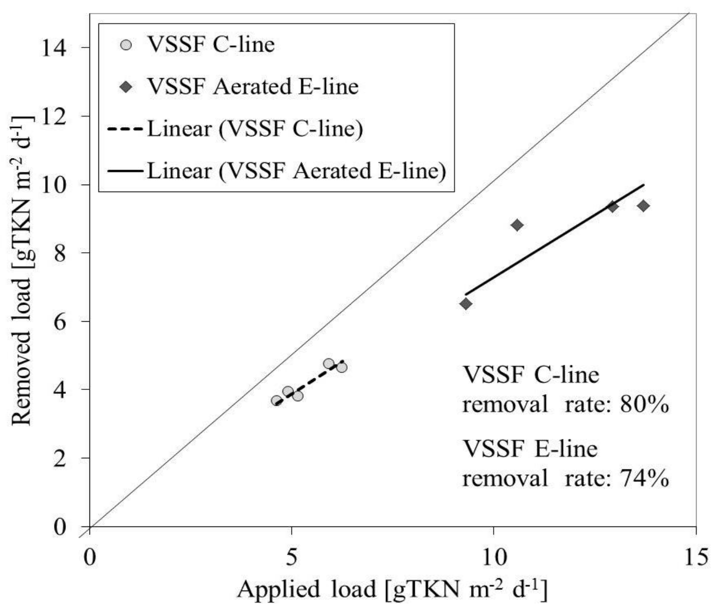
NO_X-N produced +18 mgN/L
TKN removed -59 mgN/L

Higher Denitrification (longer HRT + saturated conditions not fully aerobic).

NO_3-N	Aerated line	C-line
VSSF Effluent	20 mg/L	39 mg/L
VSSF+HSSF Effluent	12.7 mg/L	17.7 mg/L

Results

	Parameter	Aerated VSSF	C-Line
TKN	Applied TKN load in VSSF [gTKN m^{-2} d^{-1}]	12.4	5.4
	Removed TKN load in VSSF [gTKN m^{-2} d^{-1}]	9.2	4.3
Total N	Applied total N load in VSSF [gN m^{-2} d^{-1}]	13.6	5.5
	Removed total N load in VSSF [gN m^{-2} d^{-1}]	7.2	1.9



Conclusions

- The high-load Aerated VSSF is a promising technique in terms of carbon and nitrogen removal.

- Aeration cannot fill all the porosity of the bed and thus the liquid volume results not entirely aerated:

  heterogeneous and anoxic conditions in the granular medium allowing simultaneous NITRIFICATION and DENITRIFICATION in the saturated layers at the bottom of the bed.

- Total Nitrogen (TN) removal was benefited from the saturated bottom of VSSF CW: the availability of organic matter, the longer residence time and the creation of aerobic and anoxic zones in the bed.

Conclusions

Advantage	Drawback
Land area reduction: from the 4m^2/PE suggested by the national guidelines to 1.9 m^2/PE	Slightly complex system: aeration pipes, small blower and automated valve.

Aerated VSSF can be used as a permanent solution for the wastewater treatment of small communities, or as an additional one to be used during peak seasons, in order to guarantee the removal of extra-loads.

Acknowledgment:

Education and Culture DG

ERASMUS MUNDUS

ISAC - Improving Skills
Across Continents

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PROVINCIA AUTONOMA DI TRENTO

Agenzia per la Depurazione –
Depuratore di Trento Nord

Thank you for your attention!!!

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