A modified constructed wetland system for greywater treatment and reuse

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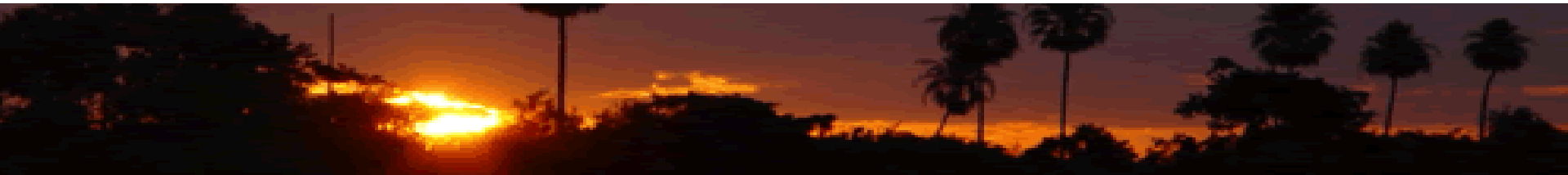


Background

Greywater (gw)

Composition and volume /person highly variable

Due to (among others):

- dynamics and behaviour of individuals, sanitary standards, age, lifestyle, eating habits, water use and availability, choice on personal care and household products

Contains chemicals and hardly any nutrients

High solids concentration (even light gw (hair and lint)

Background

Greywater treatment (small scale)

choice – some points to be considered

- required quality of the effluent (reuse applicable?)
- Sustainability of household or small scale system:
  - Cost
  - Operation and maintenance requirements
  - Odour nuisance
  - Health risks

Background

Greywater treatment

Natural treatment systems

- Good visual impact
- Landscaping: total integration with ndividual gardens or common areas (condominial)
- May promote water conservation by the direct reuse of GW
- Increase of green sites in urban areas – expected contribution to an improvement of microclimate.

Background

Greywater treatment

Constructed wetlands

- Most common system for small scale greywater treatment (peri-urban, rural areas)
- Simplified and low-cost treatment system
- Clog easily depending on substrate type and influent characteristics
- Requires a pre-treatment unit (e.g. septic or sed tank)

How to adapt for the use in urban area?

high variation
Composition and volume

→

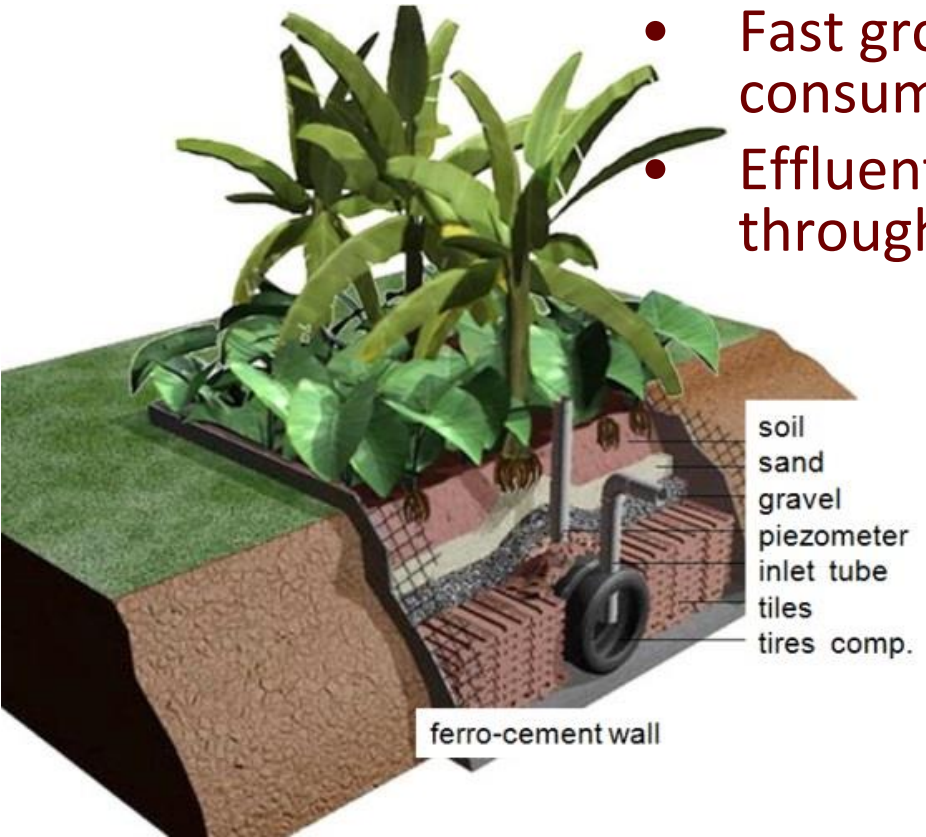
High impact
Household or swws

Background

Evapotranspiration tank (Tevap)

soil and plants based system

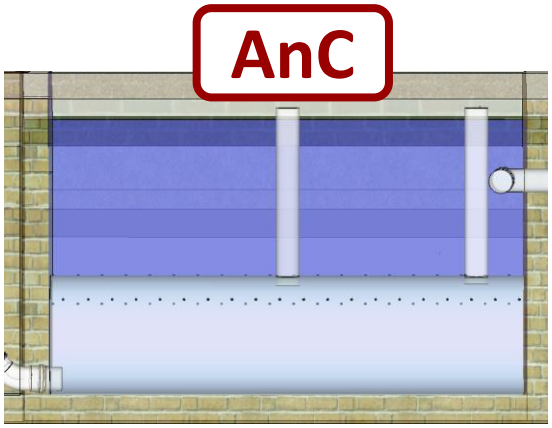
- Inbuilt AnC (car tires)
- Layers of different substrates
- Fast growing, high water consumption plants
- Effluent percolates upwards through the layers

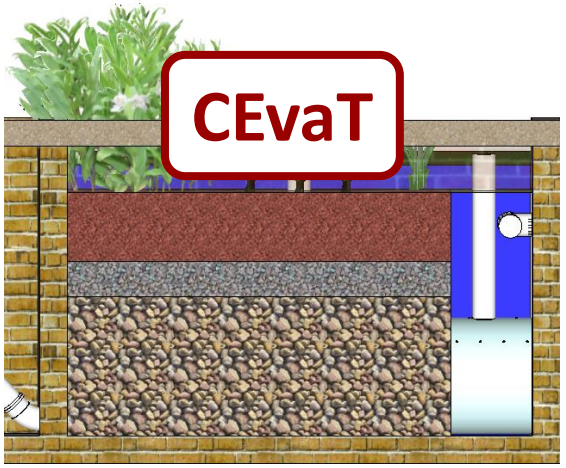


Background

Hypothesis

- AnC replaces a pre-treatment unit
  - retaining solids
  - equalising the inflows
    - avoiding clogging
    - improving the stability of the system
    - low maintenance

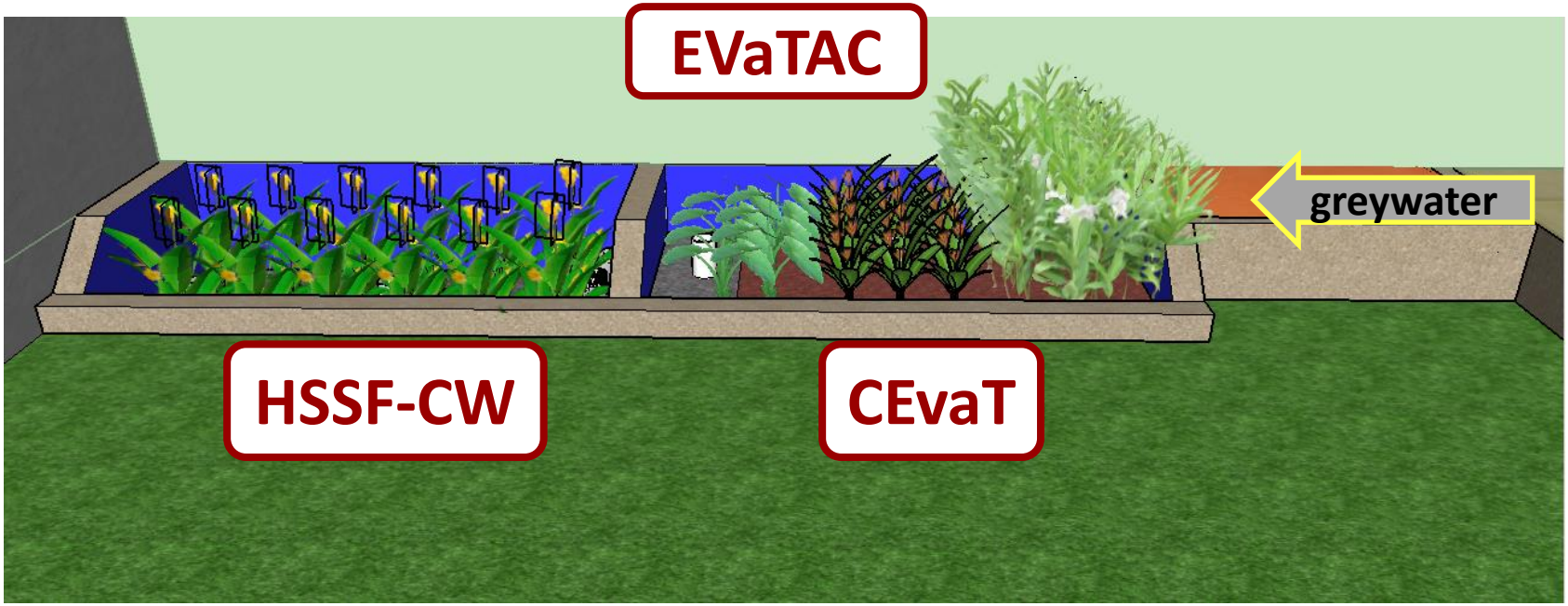




Background

EvaTAC

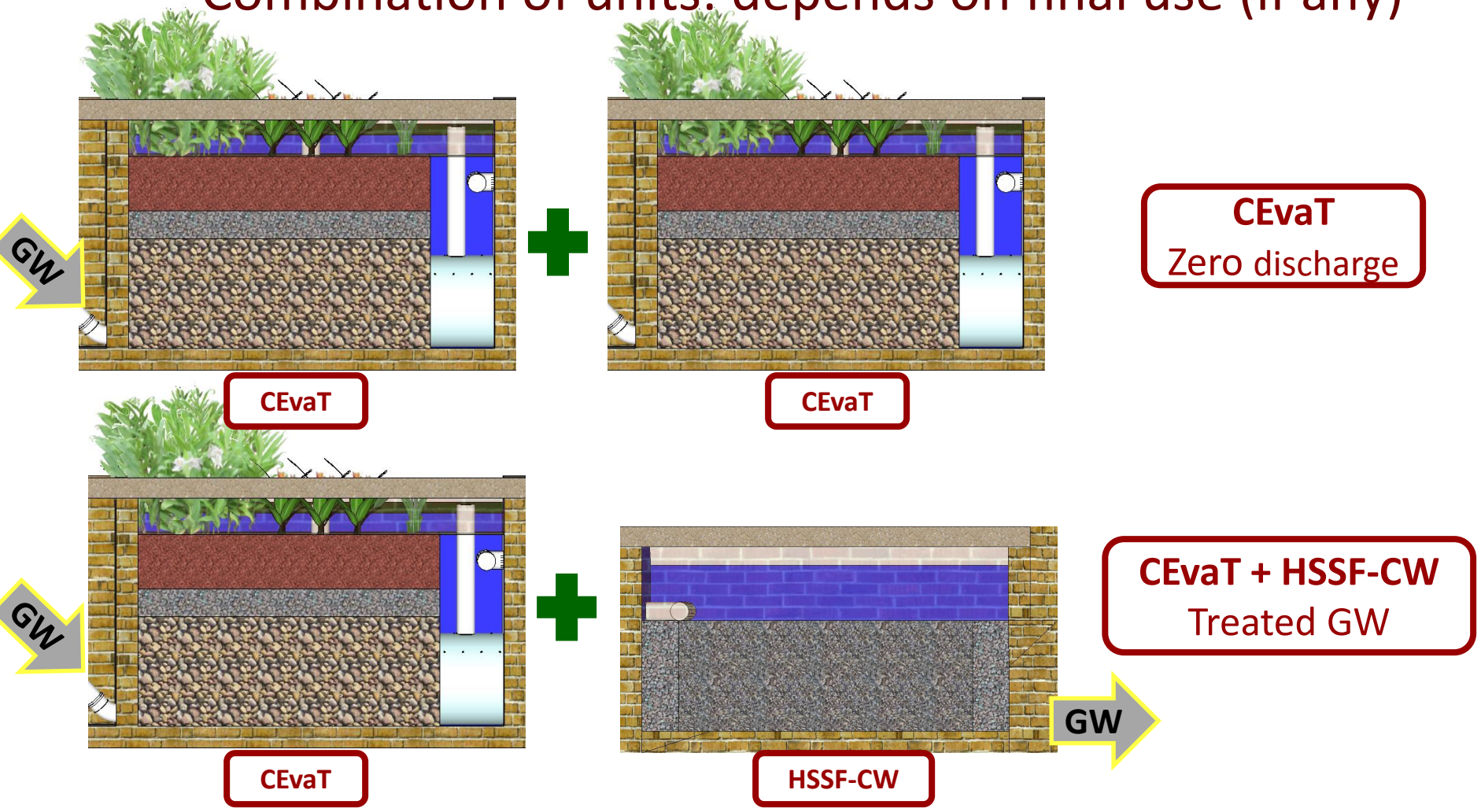
- Combination of CEvaT + HSSF-CW
- Main focus: direct reuse of gw for gardening using the system itself



Background

EvaTAC

Combination of units: depends on final use (if any)



CEvaT
Zero discharge

Objectives

- To propose a modified design of a cw system for GW - EvaTAC
- To better understand the capacity of the AnC to equalise the daily variation of flow and organic load in the EvaTAC.
  - real scale EvaTAC system
  - 24 hours and 8 days monitoring profiles

Material & Methods

Experimental setup - EvaTAC

Dimensions

CEvaT: 2.0 m × 1 m × 1.05 m (level exit - 0.74 m)

HSSF-CW: 2.0 m × 1 m × 0.60 m (level exit - 0.4 m)

Material

Masonry, lined with Fiberglass

Full scale - 3 persons household

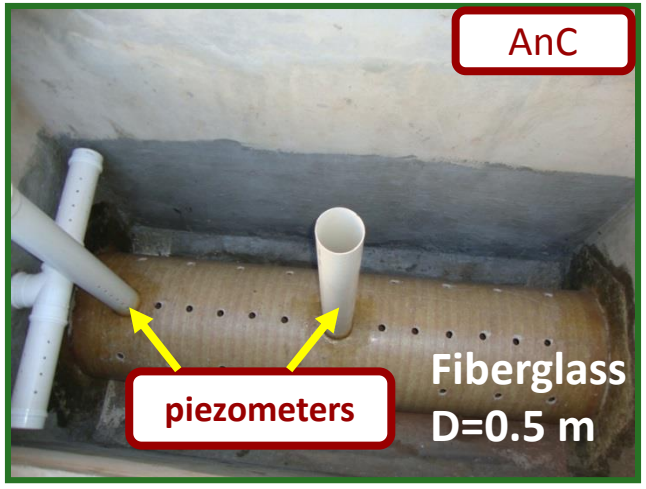
3 years in operation, Light greywater

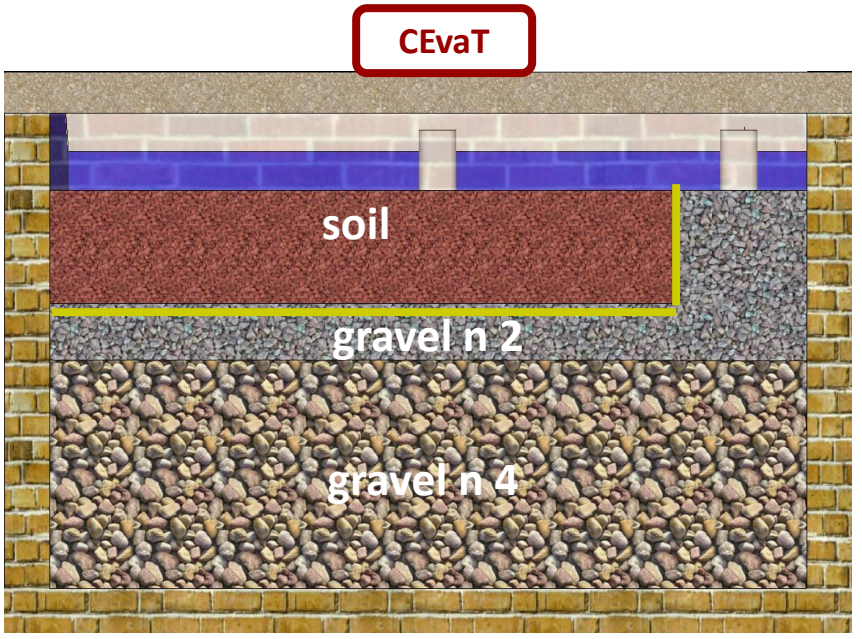
Ornamental Plants

White ginger, Caladium, Canna x generalis (beri), heliconia pisittacorum (parrot´s peak)

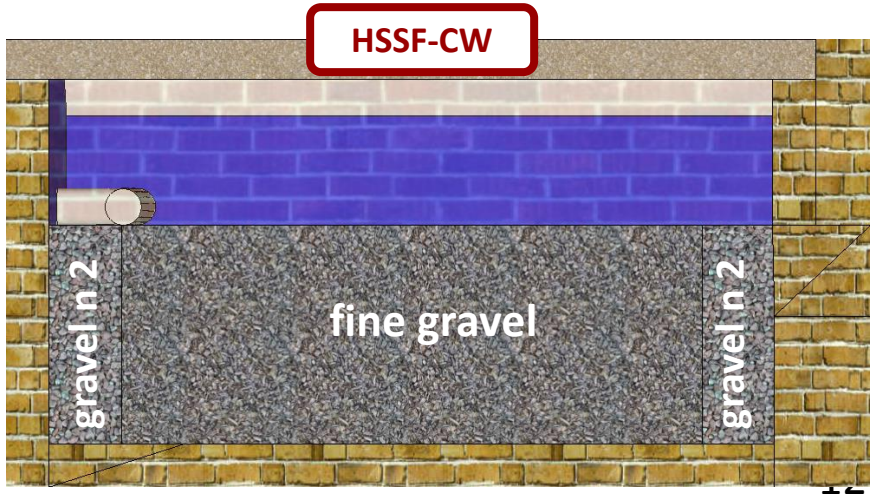
Material & Methods

Experimental setup - EvaTAC



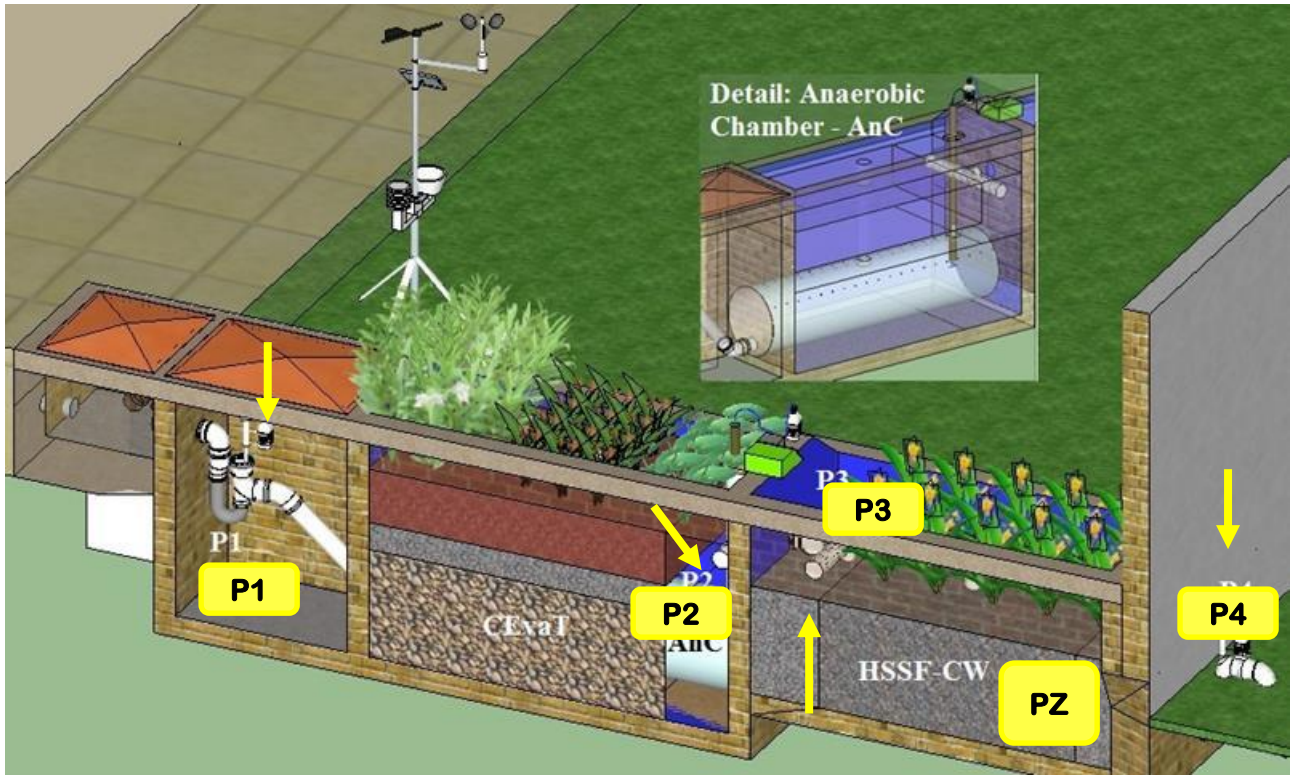


- Filtering material
  - Gravel (different particle sizes)
  - Soil
- Geotextile blanket
- Bottom slope: 1%



Material & Methods

monitoring profiles



Profile A

24 h, sinks and showers

Profile B

24h , sinks, showers and laundry (washing machine)

Profile C

8 days, same as B

- Greywater characterisation (routine simulation)
- Interviews
- Questionnaires (filled during the profiles)

Material & Methods

Monitoring profiles

Quantitative characterisation

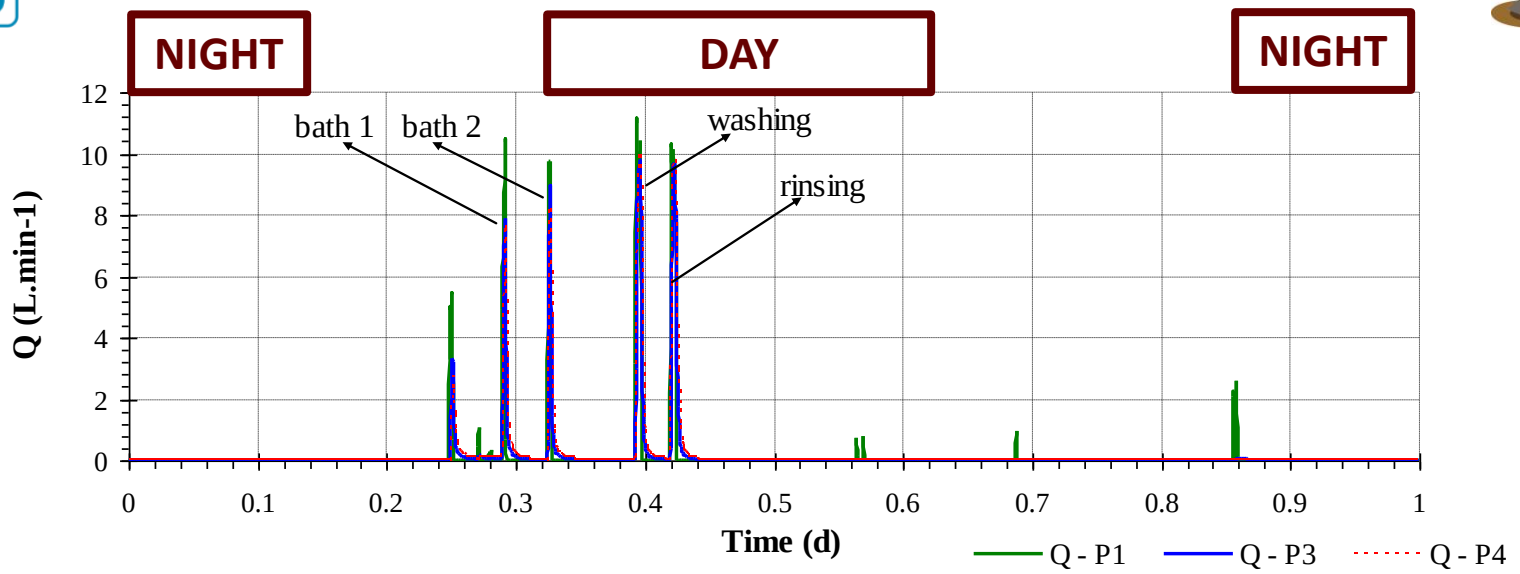
- Flow meters (generation points)
- P4 - Ultrasonic flow meter
- Levellogers (piezometers – closest to the exit in both units)
- Meteorological station (hidrological conditions)

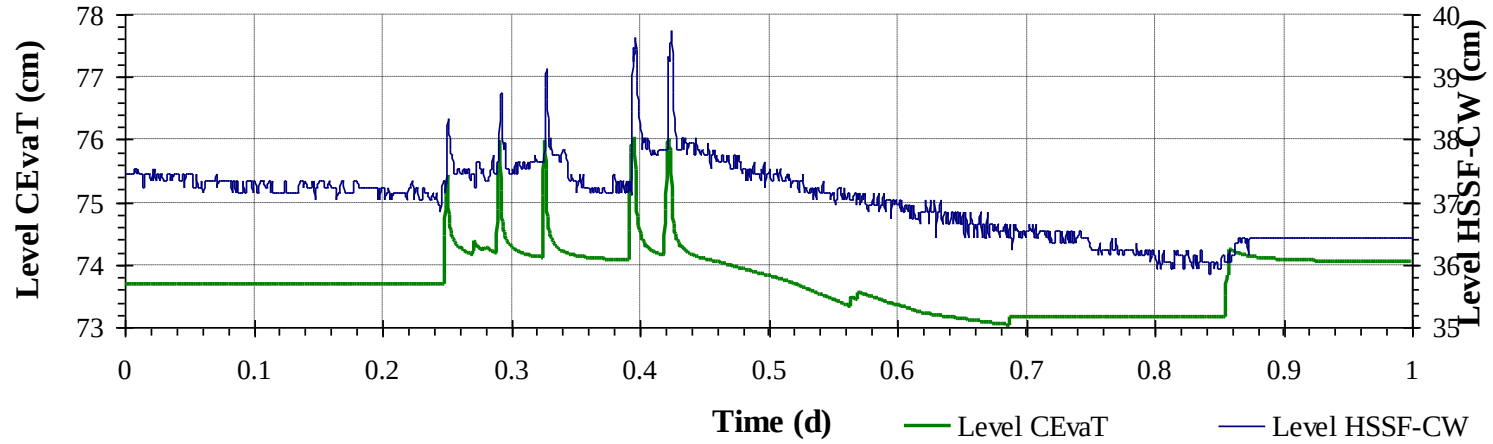
Qualitative characterisation

- grab or composite samples - depending on situation
- **Parameters**
  - COD_{total}, $COD_{soluble}$, Solids, turbidity, pH
  - Sensors: temperature, conductivity, redox potential.

Results

Profile B - Flow patterns and level





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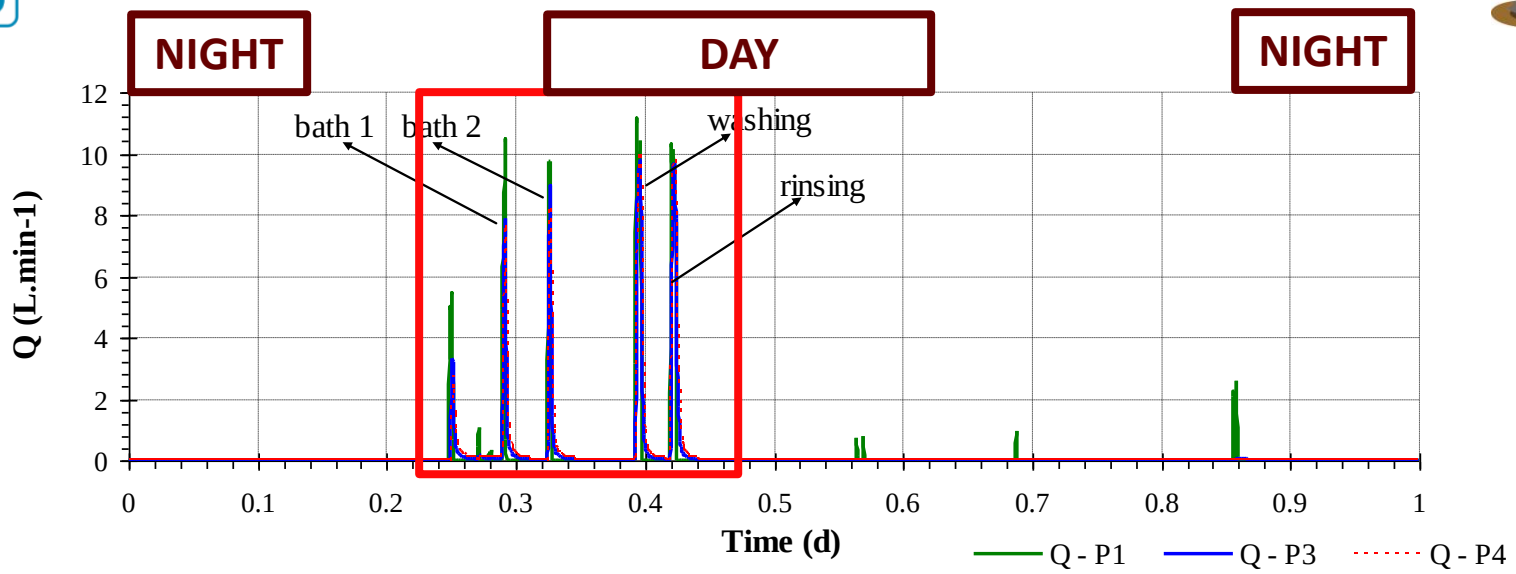

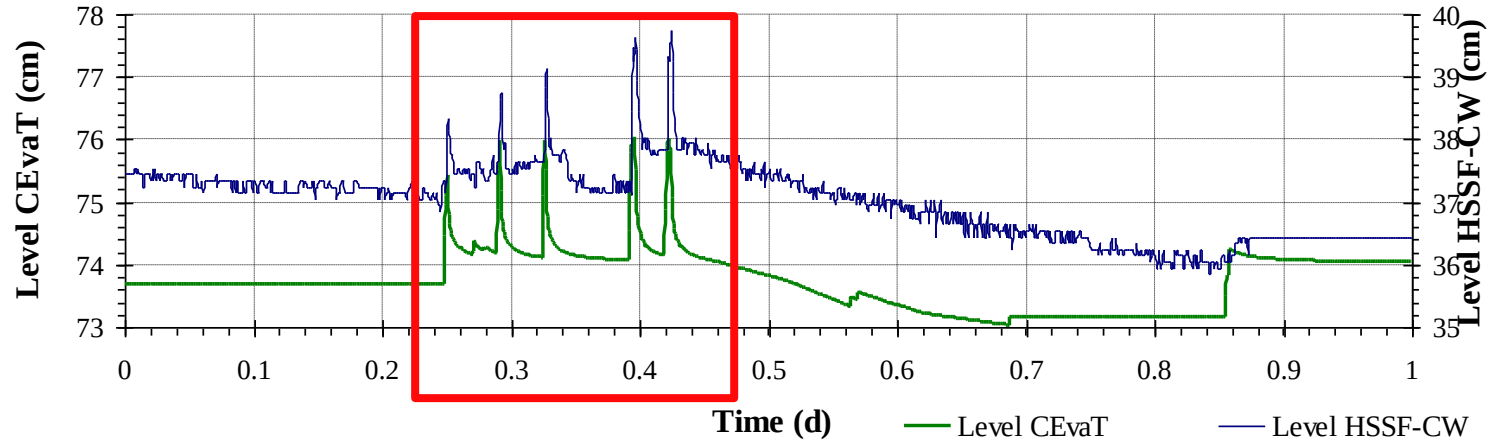

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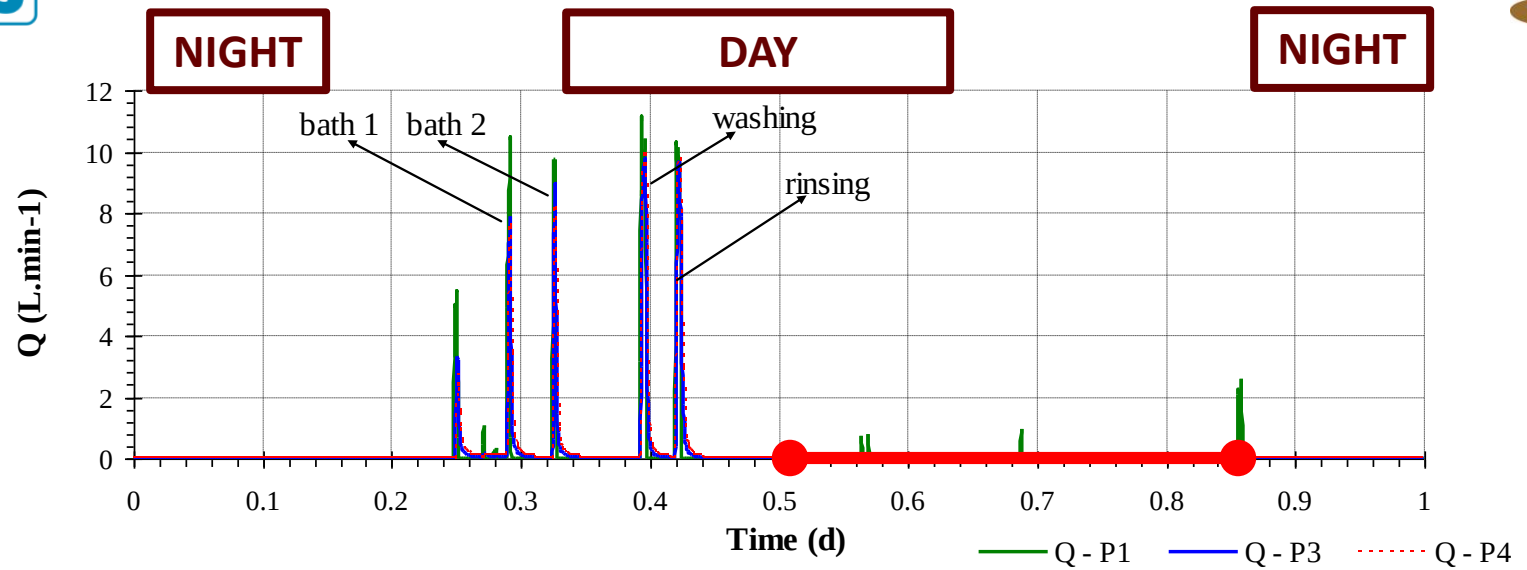

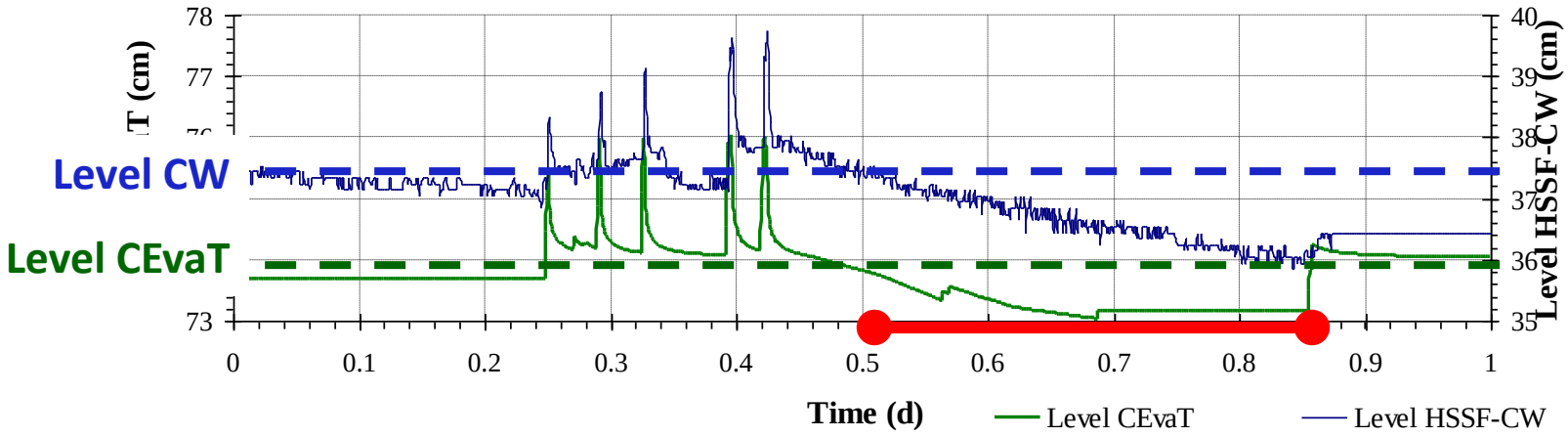

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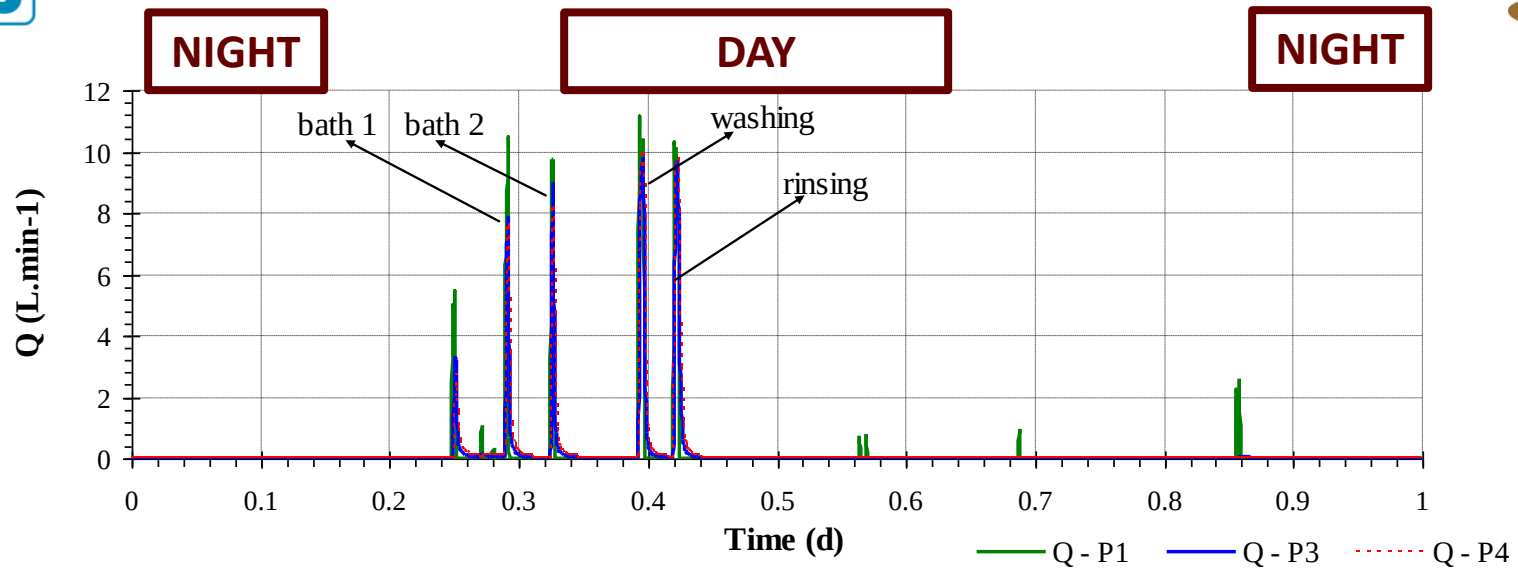
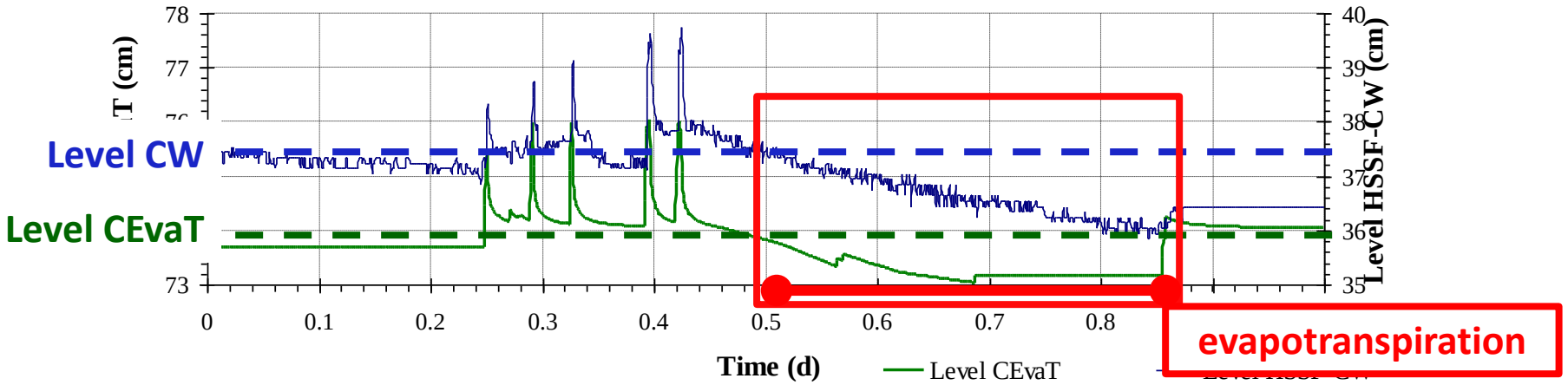
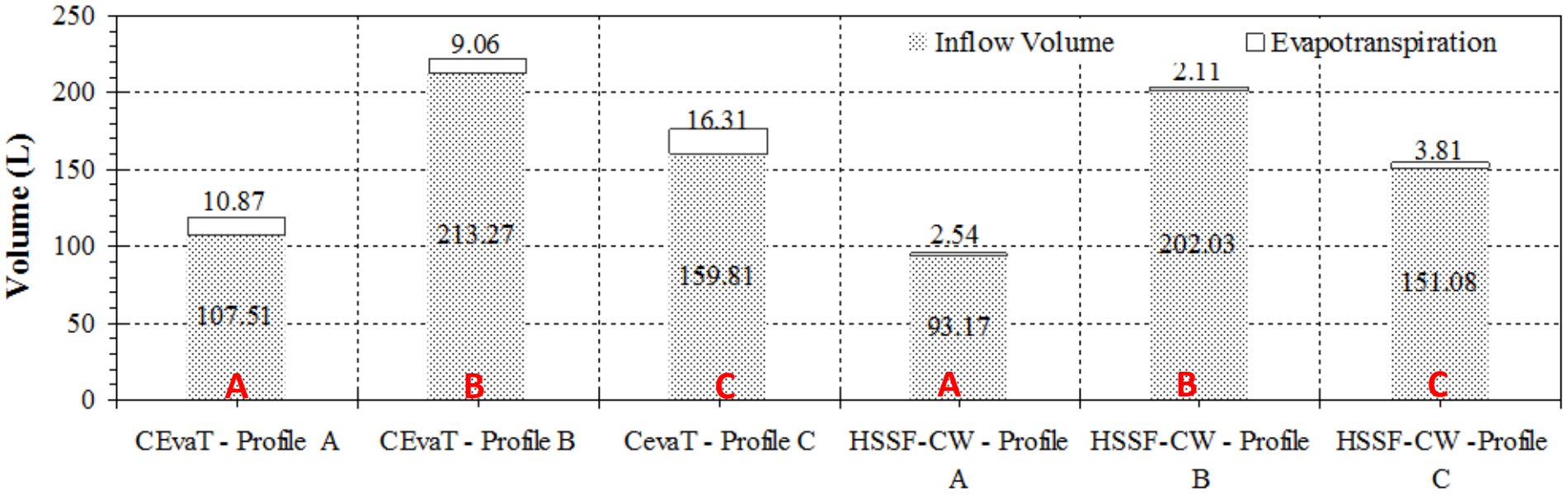




Results

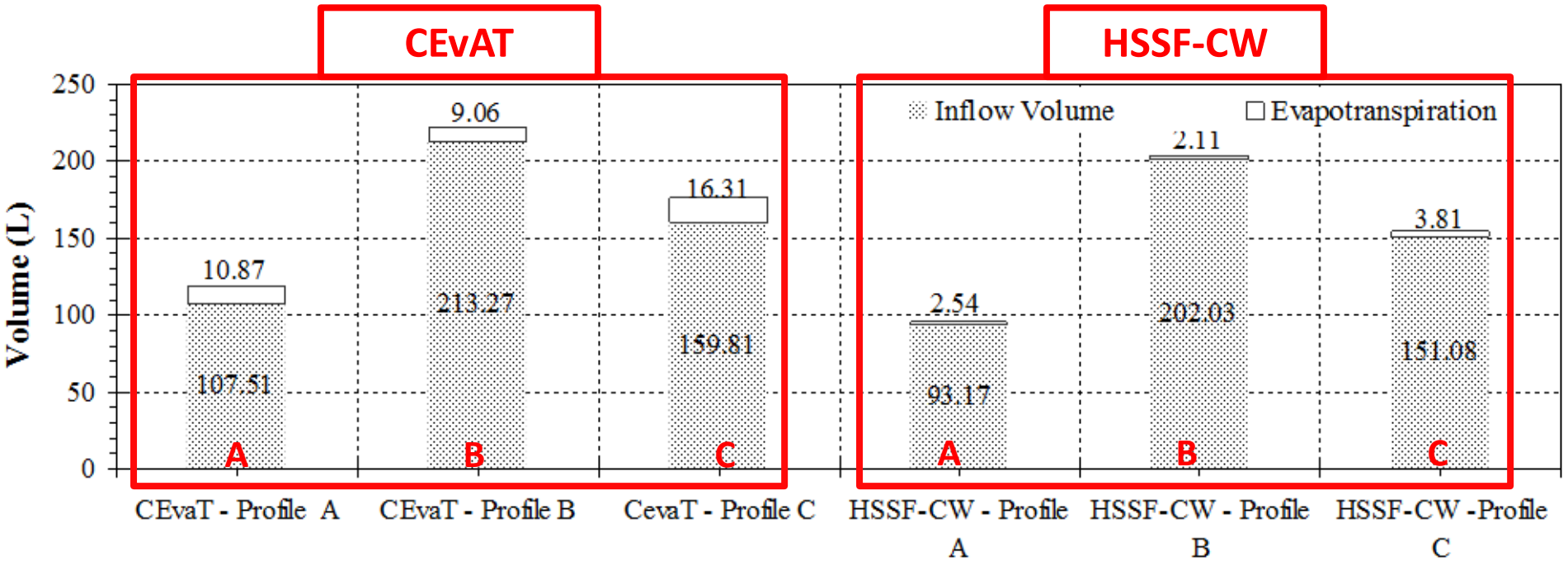
Profiles A, B and C

Inflow volume and Evapotranspiration



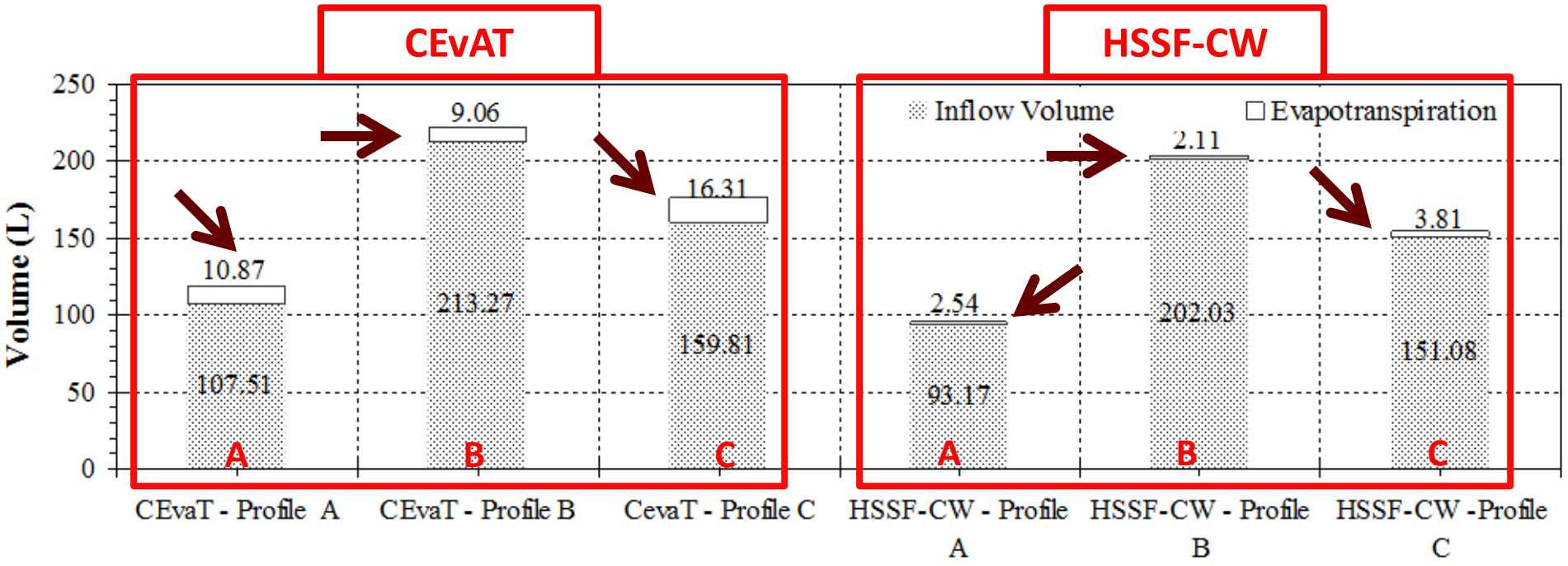
Results

Evapotranspiration – Profiles A, B and C



Results

Evapotranspiration – Profiles A, B and C



CEvaT – higher potential for evapotranspiration (soil, plants density)

About 4 times the Evap in the HSSF-CW

Results
qualitative - Profiles B and C

	Profile B (1 d)				Profile C (8 d)			
	Q_{P1} = 8.3 L.min^{-1}				Q_{P1} = 6.6 ± 2.2$^{(36)}$ L.min^{-1}			
sampling point	P1	P2	P3	P4	P1	P2	P3	P4
COD_t (mg.L^{-1})	290	113	55	41	307 ± 190$^{(8)}$	147 ± 67$^{(8)}$	118 ± 21$^{(8)}$	73 ± 16$^{(8)}$
T (NTU)	60	35	40	9.3	56 ± 17$^{(8)}$	45 ± 17$^{(8)}$	43 ± 12$^{(8)}$	10 ± 1.5$^{(8)}$

COD and Turbidity to illustrate behaviour

No means to assess removal efficiency

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Turbidity

Low variation between AnC and CevAT (P2 - P3)

Most retained in HSSF-CW (P4)

Results
qualitative - Profiles B and C

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T (NTU)						45 ± 1		5$^{(8)}$

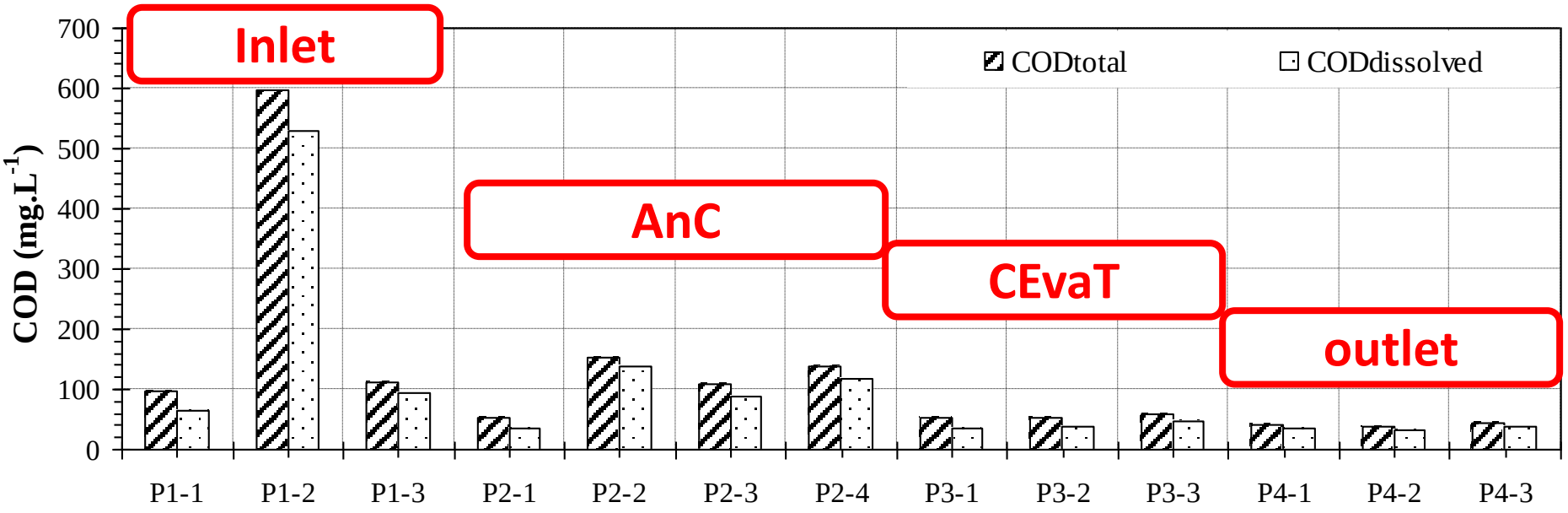
Profiles B and C
higher variation than Profile A
P1 - COD_{total} as high as 900 mg.L^{-1}

Does not reflect in final effluent (Profile C – 8d)

HRT (average)
CEvaT – 3 to 6 days
HSSF-CW – 1.8 to 2 days
EVaTAC - 5 to 8 days

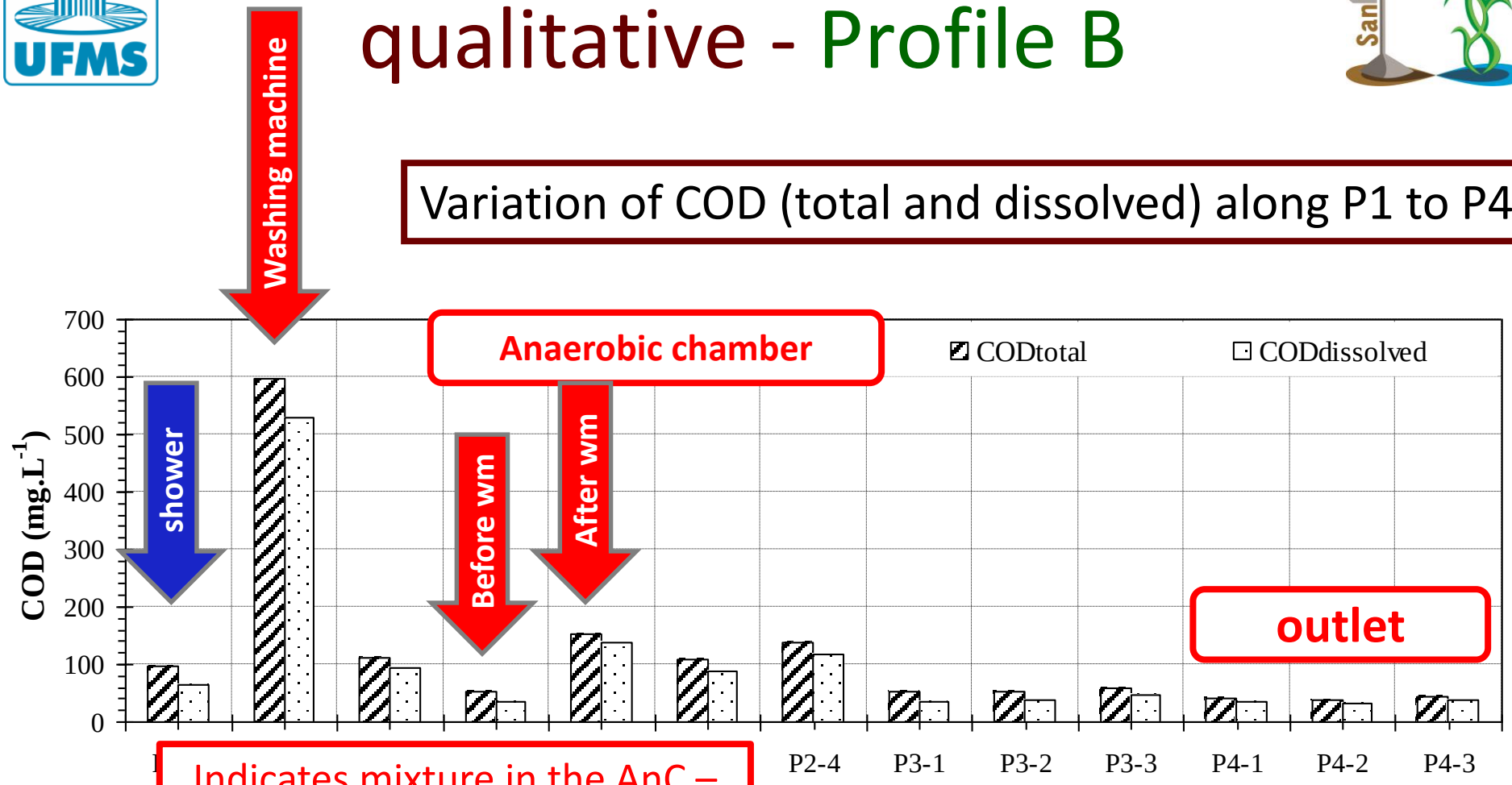
Results qualitative - Profile B

Variation of COD (total and dissolved) along P1 to P4



Results
qualitative - Profile B

Variation of COD (total and dissolved) along P1 to P4



Indicates mixture in the AnC – mixed flow reator?

Stable values for COD in P4 along Profiles B and C

Conclusions

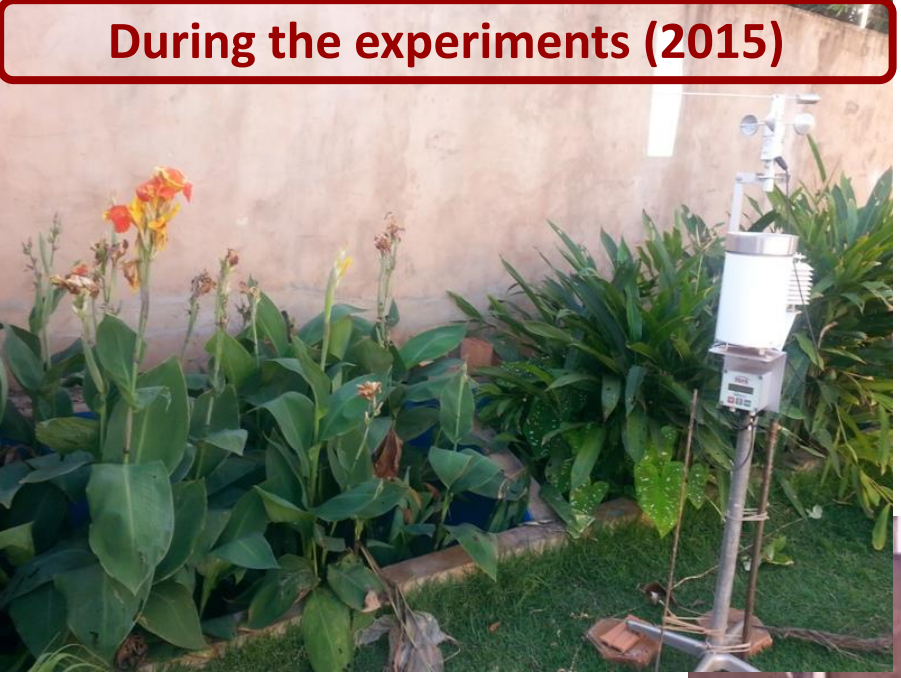
- Monitoring profiles - appropriate tool to better understand the capacity of the AnC to equalise the daily variation of flow and organic load in the EvaTAC .

- For low flows (sinks and showers) no mixing observed in the. For higher flows (e.g. washing machine) the AnC attenuates the peak load and stabilises the system.

Conclusions

- AnC replaces a pre-treatment unit.
- The HSSF-CW operates as an efficient polishing unit.
- CEvaT and HSSF-CW complement each other.
- 3 years of operation: no sludge withdrawal, no maintenance in the distribution pipe (inlet) of the HSSF-CW.
- householders routine undisturbed, rendering a green site totally integrated into the garden, without the use of potable water for irrigation.

During the experiments (2015)



Present days (2016)

Thanks
for the attention!

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