Treatment and reuse of domestic greywater through green walls

Elisa Costamagna (1), Fulvio Boano (1), Alice Caruso (1), Silvia Fiore (1), Marco Chiappero (1), Ana Galvao (2), Joana Pisoeiro (2), Anacleto Rizzo (3), and Fabio Masi (3)

(1) Politecnico di Torino, DIATI - Department of Environment, Land and Infrastructure Engineering, Torino, Italy (elisa.costamagna@polito.it),(2) Centre for Hydrosystems Studies, Technical University of Lisbon, Lisbon, Portugal, (3) IRIDRA Srl, Florence, Italy

Tue, 05 May, 2020
8:30-10:15

Funded by

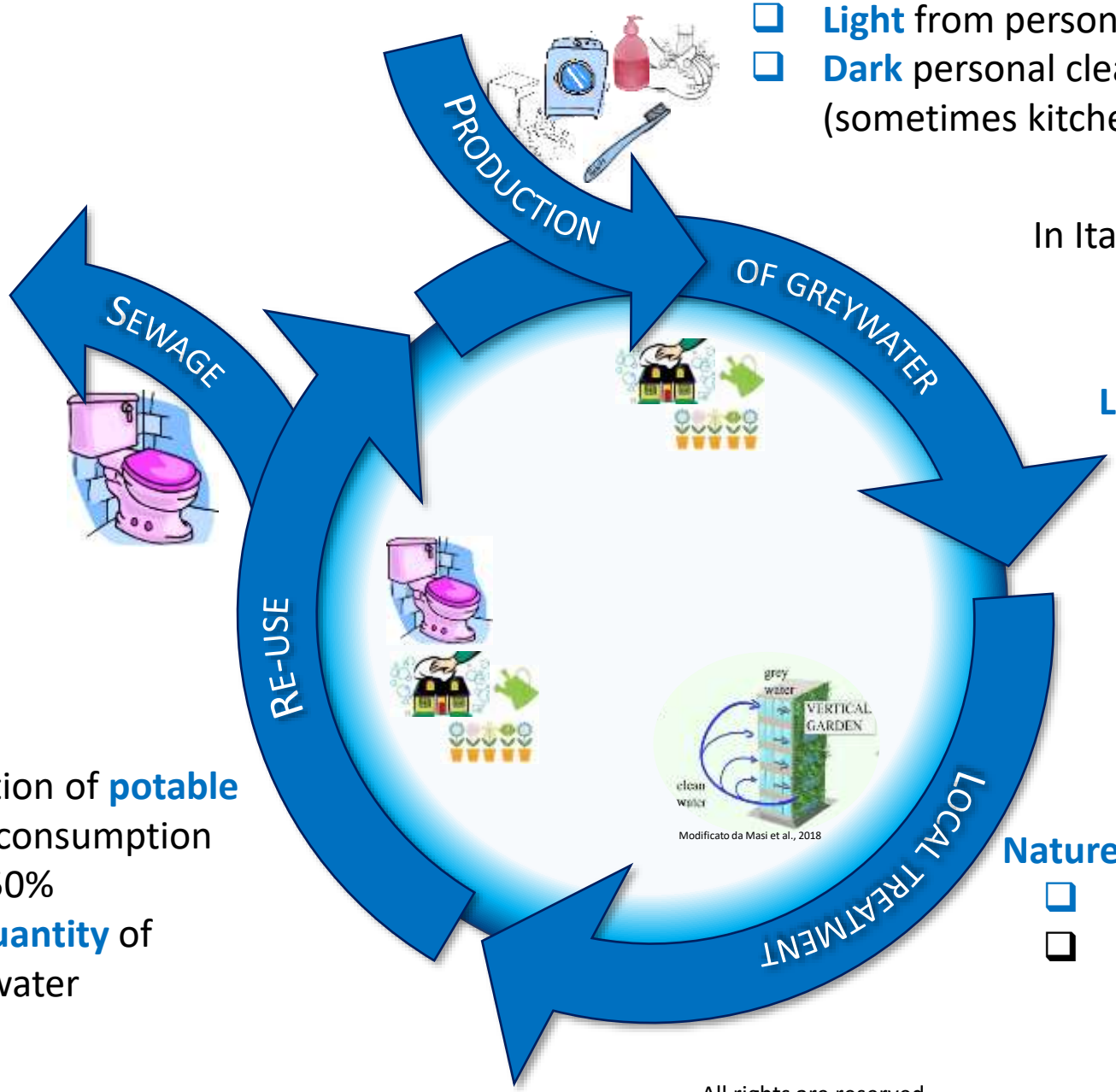
Picture courtesy of Irene Soligno, PhD

elisa.costamagna@studenti.polito.it

Greywater: domestic greywater excluding toilet flushing.

- **Light** from persona cleaning (hand basin, shower, bath)
- **Dark** personal cleaning, laundry, house cleaning, dishwasher (sometimes kitchen sink)

In Italy around **100 L/PE daily**



Modificato da Masi et al., 2018

Local treatment

- Less **quantity** of wastewater that is collected and treated in centralised treatment plants
- Different **quality** of the remaining wastewater collected (more concentrated pollution)

Nature-based solutions

- **Less chemicals** products for treatment
- Environmentsal and human **benefits** in urban areas (e.g. air quality, biodiversity, heating islands, noise, stress, building value)

Re-use

- Reduction of **potable water** consumption up to 50%
- Less **quantity** of wastewater

Aim of the study:
Evaluation of treatment performances of different growing media in a pilot green wall system

1. Outdoor pilot system

- ❑ Synthetic GW prepared every two days
- ❑ One column = one growing medium (three independent replicates per media)
- ❑ Base growing medium: coconut fibre and perlite
- ❑ Multiple panels system
- ❑ 24 L per column per day
- ❑ HLR 750 L/m^2/day

Phase 1: Jan-Apr 2019
9 samples
7 configurations

Phase 2: May-Jul 2019
8 samples
3 configurations

Additive in growing media
- ❑ 20% polyacrilate (older) - columns prepared during pre-test
- ❑ 20% polyacrilate
- ❑ 20% compost
- ❑ 20% polyacrilate + 20% biochar
- ❑ 10% granular active carbon
- ❑ 20% biochar – columns analysed in both phases
- ❑ 20% biochar (new)
- ❑ 20% biochar + 5% graphene

2. Water flow and sampling

- ❑ Vertical flow along each column
- ❑ Sampling at the outflow of the lowest row
- ❑ Period: Jan –Jun 2019
- ❑ Frequency: every one/two weeks

3. Water samples analysis

On site analysis
- ❑ Temperature
- ❑ Electric conductivity
- ❑ pH
- ❑ Dissolved oxygen

Laboratory analysis
- ❑ COD
- ❑ BOD_5
- ❑ TKN
- ❑ NH_4^+
- ❑ NO_3^-
- ❑ TSS
- ❑ TP
- ❑ SO_4^{2-}
- ❑ Cl^-
- ❑ MBAS
- ❑ E.coli

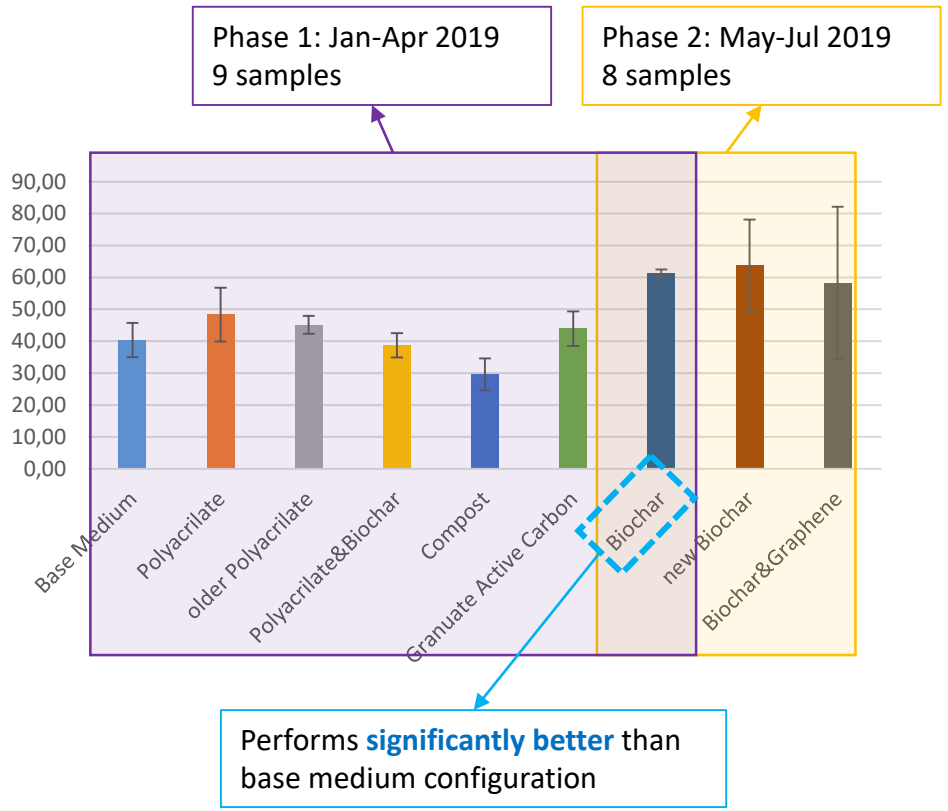
4. Statistical tests

❑ Mann-Kendall trend test:
It verify if a monotonic trend exists treating each series separately

❑ Wilcoxon signed rank test:
It compares two series data by data, testing if a configuration with additive **performs better than the base medium** (blue squares in the graphs)

Evaluation of treatment performances: Comparison between mixes with addictive

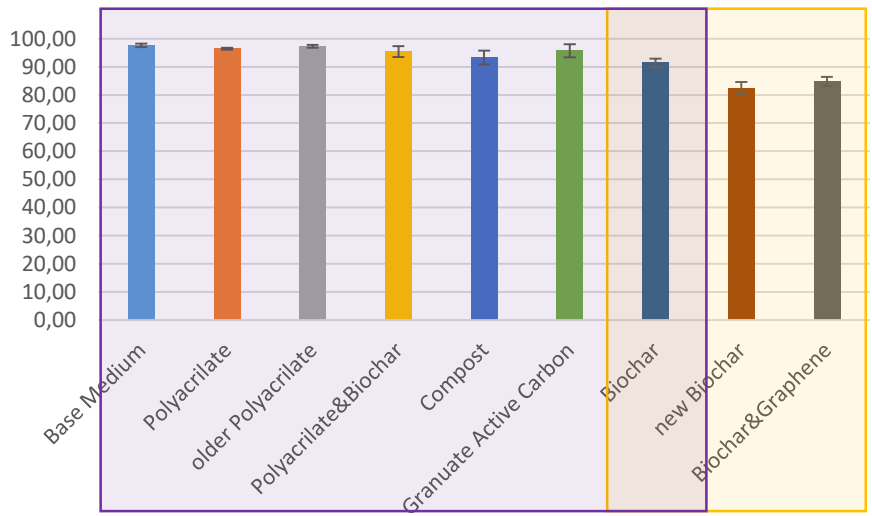
COD Removal efficiency (%)



- The most of the configurations in **phase 1 increases performance along time** (except polyacrilates)
- **Phase 2** shows **better** removal preformances
- Substancial differences in GW input concentration

GW input [mg/L]	
Avg (std)	274.22 (90.25)
Max - Min	137.00-381.00
Avg (std)	75.13 (17.81)
Max - Min	56.00-97.00

BOD_5 Removal efficiency (%)

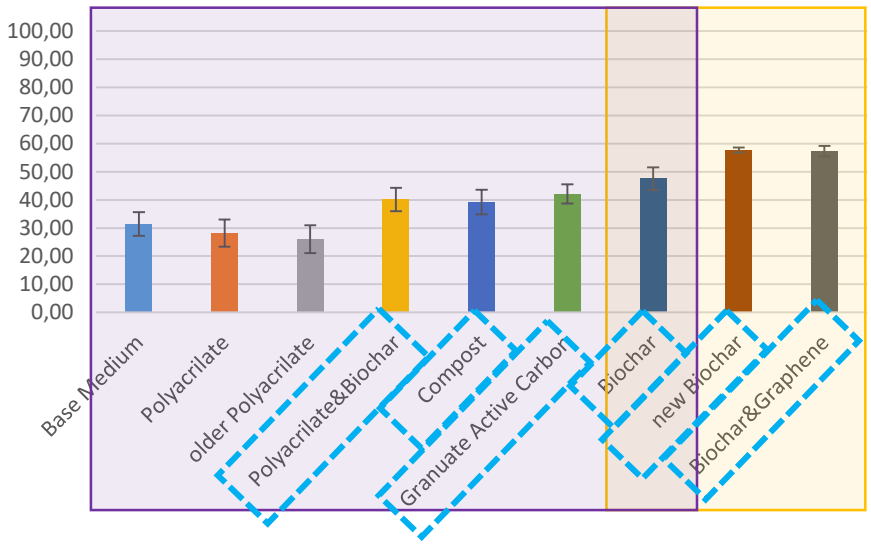


- **Phase 1**: over **90%** on average for all the configurations along time
- **Phase 2** shows decreasing performances along time and worst average performances
- Additives do not increase system perfomances compared to base medium alone
- No substancial differences in GW input concentration

GW input [mg/L]	
Avg (std)	52.37 (8.97)
Max - Min	36.20-71.30
Avg (std)	59.59 (21.88)
Max – Min	18.80-81.70

Evaluation of treatment performances:
Comparison between mixes with addictive and base mix medium

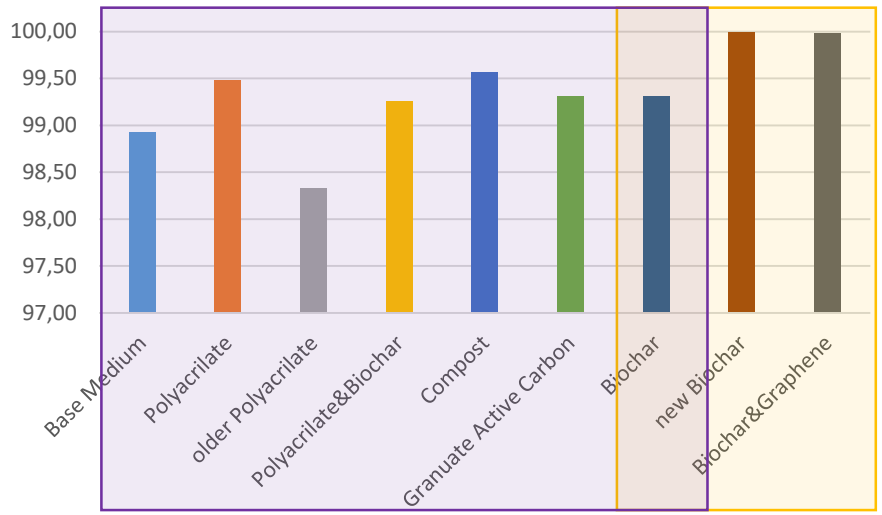
Total Nitrogen Removal efficiency (%)



- In **phase 1**, the most of the configurations **increases performance** along time (except polyacrilate+biochar and compost)
- In **phase 2**, configurations show **no trend** in removal performances

GW input [mg/L]	
Avg (std)	8.40 (4.46)
Min-max	4.70-16.60
Avg (std)	14.34 (6.11)
Min-max	11.50-29.40

E. Coli Removal efficiency (%)



- All configurations reach a plateau **close to 100%** in removal efficiency
- Configurations in **phase 1** shows an **increasing** trend (except biochar)

GW input [MPN/100mL]	
Avg (std)	1.3e5 (9.7e4)
Min-max	2.5e5-1.3e4
Avg (std)	8.0e4 (4.9e4)
Min-max	2.0e4-1.3e5

Conclusions and further analysis

- The system has a great tolerance to **high HLR** (ten times more the value used is common VF CW)
- **pH** in the range **7.2÷7.6** for all the configurations
- Increasing of **DO** in output shows a good aeration of the vertical flow system
- **BOD_5** and **E. coli** show **excellent** treatment performances (removal efficiency almost 100%)
- **COD** removal **increases** over time
- **Input COD** concentration decreases with temperature, possibly due to biochemical degradation into the tank
- **TN** removal is significantly increased by the presence of additives to base medium (except polyacrilate)

Next experimental phase

- Evaluation of the treatment performance along each column