



WOW! CLOSING EVENT – PART 2
FRIDAY SEPTEMBER 8TH – DUBLIN

Biochar from Cellulose - manufacturing process and possible application

Prof. Joachim Hansen,
Dr. Silvia Venditti, Dr. Irene Salmerón

Chair for Urban Water Management
University of Luxembourg

let`s talk about...



Motivation I

- **Toilet paper is one of the wastewater ingredients with the highest amount**

- around 85 rolls per person and year: 1 km
- in EU27: ca. 4 Mio tons per year



- **What is normally done with toilet paper in STP?**

- removed in first stages of STP together with faeces and plastic (waste!)
- incinerated and disposed on landfills



Motivation II

- **Toilet paper consists of cellulose**
 - valuable material
 - could be used for different purposes
- **One possibility (beside others):**
 - production of biochar



one of the aims of WOW!-project; test for specific application in wastewater treatment

How and where to recover cellulose?



After the initial screening and grit chamber: large solids and sand already removed

Recovery of cellulose in STP I

- **Dutch enterprise CIRTEC develop specific technology**
- **Pilot-scale investigations in frame of WOW! at STP Ede (NL)**
- **four step process**



Photo: www.cirtec.nl

Recovery of cellulose in STP III

1) Cellulose washer:

hair, small plastics and organics are removed

2) Fine sieving:

rotating filter mesh for capturing the cellulose
wastewater is fed on top of the mesh; water drains
through the mesh – cellulose particles form a layer

3) Dewatering

particles from sieving are dewatered by press



Photos: www.cirtec.nl



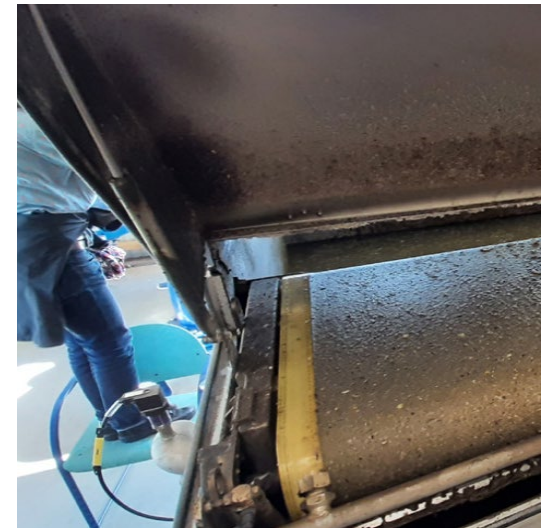
Figure 7: Finesieves in Ede

Recovery of cellulose in STP IV

4) Drying and pelletizing

- pressed material is dried in two steps
- Conversion into pellets with diameter of 6 mm

→ **Cellulose-pellets with 90% dry matter**



What to do
with the
cellulose?



Utilization as biochar:

→ supporting material in Constructed Wetlands (as additional step after conventional treatment) for advanced wastewater treatment



What is a Constructed Wetland?

Constructed Wetlands (CW) are artificial wetlands that are used for several purposes in wastewater disposal

- advanced treatment of stormwater or combined wastewater
- decentralised treatment of municipal wastewater for small units

→ **Macropollutants (BOD, COD, N + P), heavy metals**

First approaches for elimination of **Micropollutants (MP)**



Lessons learnt from previous projects

1) Utilization of biochar in CWs can increase their performance
(esp. MP elimination)
→ biochar as admixture for soil (e.g. 5...15%)

2) Activation of biochar (biologically – by fermentation) **can lead to a further increase of performance**

→ Use of (biologically activated) biochar from cellulose as supporting material for Constructed Wetlands

Valorization of Cellulose I

In frame of WOW!-project:

Cellulose pellets were delivered to small German company (Klimafarmer) for valorization

Based on their experiences:

Production of 3 types of biochar for further testing

- 1) From 100% cellulose
- 2) From 50% cellulose / 50% straw
- 3) From 50% cellulose / 50% wood

Valorization of Cellulose II

First step: Carbonization

- Temperature between 600 and 800 °C
- Residence time in reactor between 2 and 6 h



Second step: biological activation

- Via anaerobic fermentation (25 – 35 °C)
- Biochar is mixed with minerals, nutrients and microorganism (e.g. bacteria, yeast)
- Fermented for 2 – 4 weeks



Final product



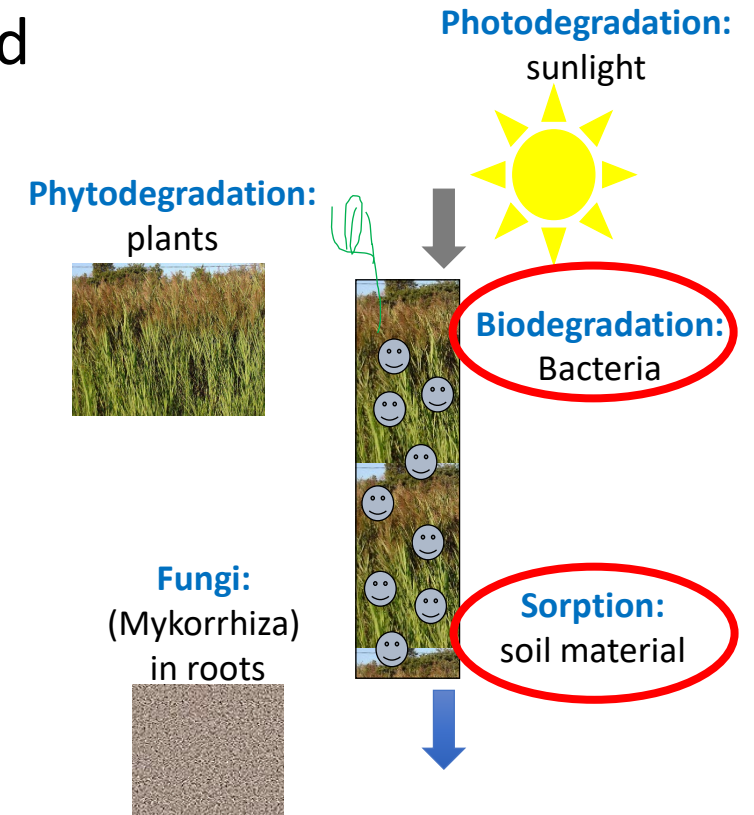
WOW! Biochar

Pre-test in lab for MP-elimination I

Performance of CWs for MP elimination is mainly based on two steps:

- 1) Adsorption on soil material
- 2) Biodegradation

→ **Test on Adsorption capacity (see next slides) and biological removal (not shown here)**



Adsorption tests

1) batch-test on shaking-table

Removal rates for Indigo carmine (dye) and selected Micropollutants





Adsorption tests

2) continuous-test with Rapid small-scale columns

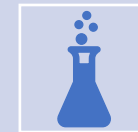
Breakthrough curves (long-term efficiency of material)



Tests with indigo carmine and selected Micropollutants



Tests with non-activated and activated material



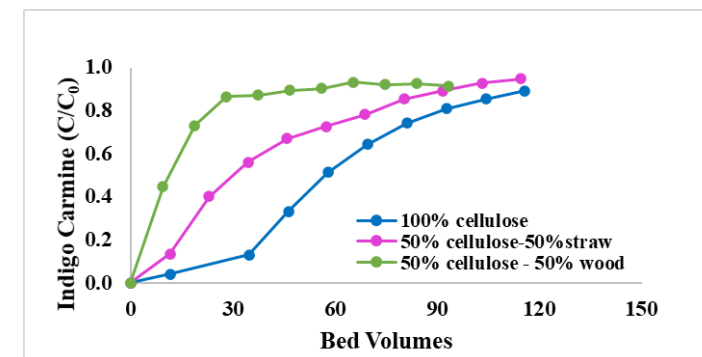
Tests with pure cellulose and mixtures with straw and wood

Results of pre-tests

- the mixture of cellulose with wood has **the lowest adsorption capacity**, for indigo carmine and for micropollutants
- 100% cellulose and the mixture with straw showed **similar behavior for adsorption**
- Mix cellulose with straw showed **the best combination of adsorption + biodegradation performance**

Further experiments (Mesocosm, pilot-scale) with activated biochar – mixture cellulose and straw

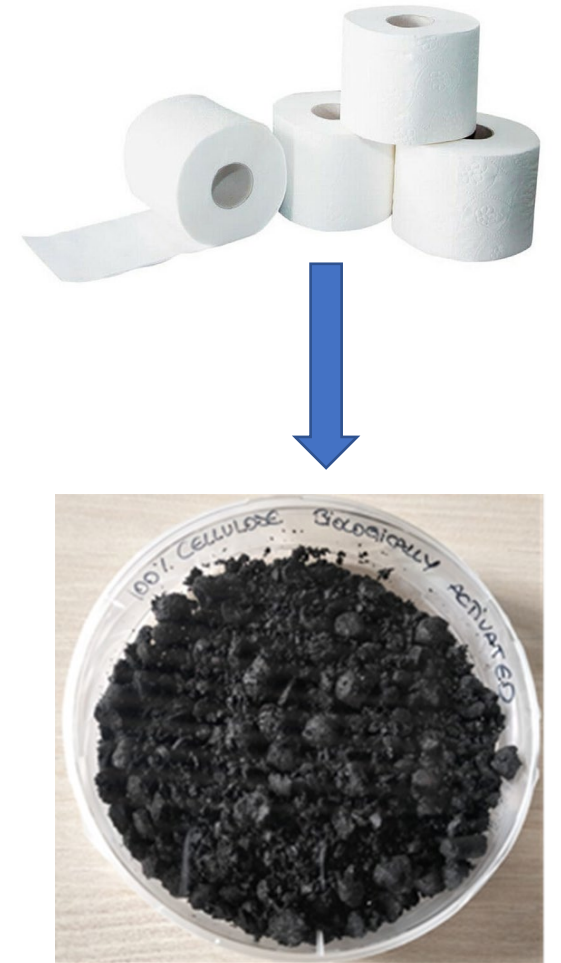
→ Presentation of Silvia Venditti



Summary

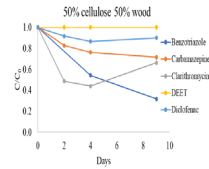
- Cellulose is a valuable product that should be extracted from wastewater
- Simple integration in conventional process of wastewater treatment
- By carbonization and biological activation, activated biochar can be produced
- Biochar can be used for different purposes, e.g. MP-elimination from wastewater

Perfect example for circular approach → main idea of WOW!





The University of Dublin



WUPPERVERBAND
für Wasser, Mensch und Umwelt



WiW
Wupperversbandsgesellschaft für
integrale Wasserwirtschaft mbH

