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From misused feedstocks to valuable air purification materials

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Netpore cost action CA20126

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Renewable Material Composites

InnoRenew CoE and University of Primorska

10th International Conference on Sustainable Solid Waste Management (CHANIA 2023)

Horizon 2020 Framework Programme of the European Union; H2020 WIDESPREAD-2-Teaming: #739574

Overview

Olive stone

- 10% of the fruit weight
- In Europe, olive solid wastes are estimated at 10 million tonnes annually

Arundo donax

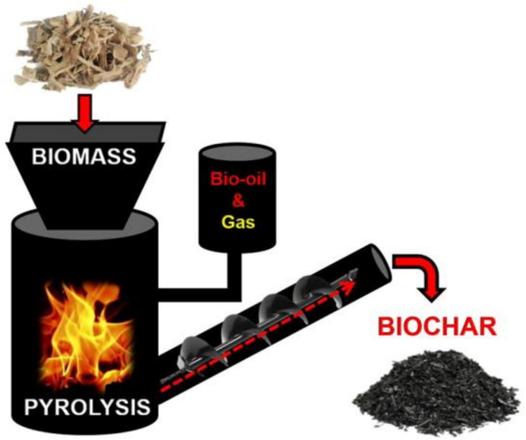
- Invasive species: 10th among the 100 worst invasive species in the world
- Fast growth rate: 38 tons of dry matter/ha/year

Huge amount of agricultural solid waste

Overview

Valorization by thermal conversion => Slow pyrolysis

- Sustainable approach
- Profitability
- Added-value products



Biochar is the solid residue generated during the thermal decomposition of organic matter under high temperature and inert conditions.

- Low cost
- Widely available
- Porous structure and large surface area
- Functional groups
- Frequently applied as adsorbent for organic and inorganic pollutants
- Tailorable properties

Suitable adsorbent for VOCs

Research Aim

Preparation of the biochar from under-utilized biomass and application in formaldehyde remediation

Direct effects on human health

Nausea
Headache
Skin irritation

Cancer
Lungs damage
Death

Preparation of the biochar particles

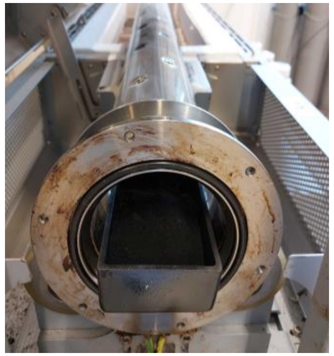
Pre-pyrolysis treatment → **Pyrolysis** → **Post-pyrolysis treatment**

High impurities and ash content:
Cleaning
Grinding
Demineralization: 1h, 60°C

Optimized parameters:
Nitrogen, 300°C-800°C, 30min,
heating rate 1500 °C/h

Wet ball milling
30min
Activation of one sample (800°C): CO_2

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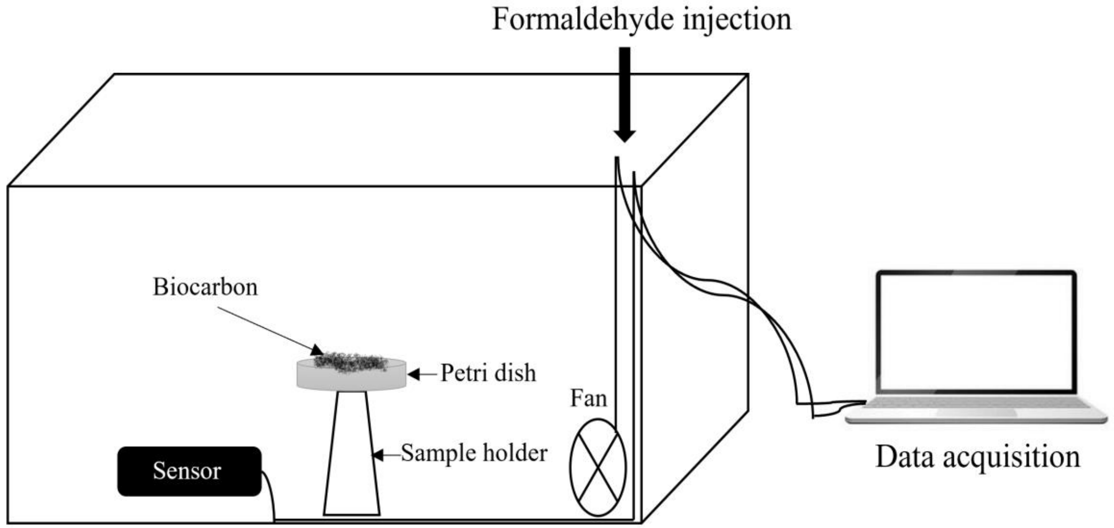
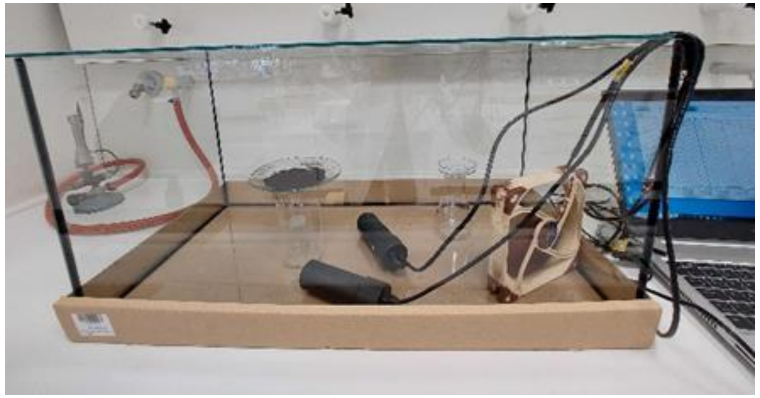
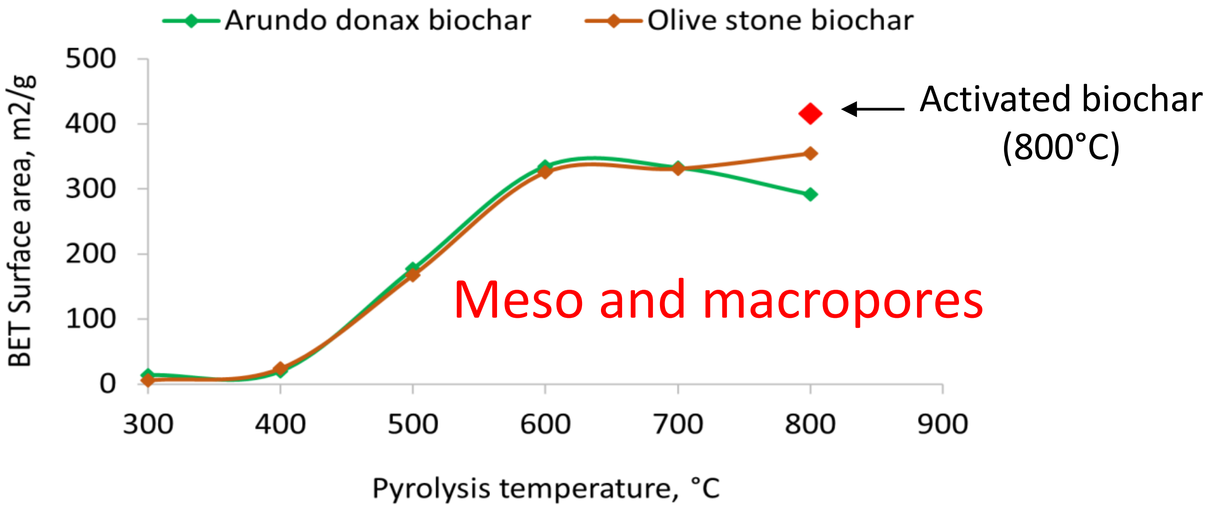
Characterization & Formaldehyde adsorption tests

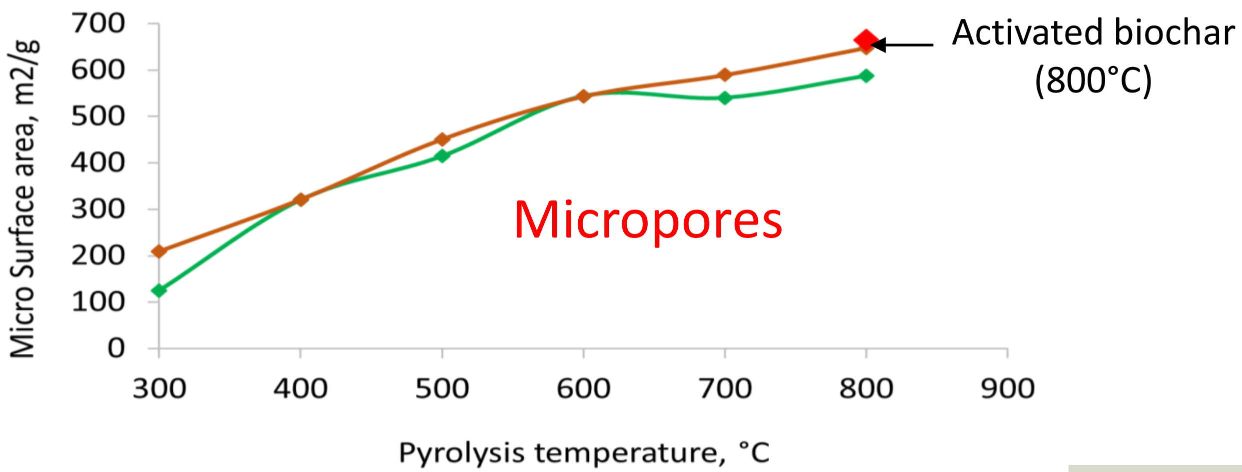
- Physical composition
- FTIR
- Physisorption





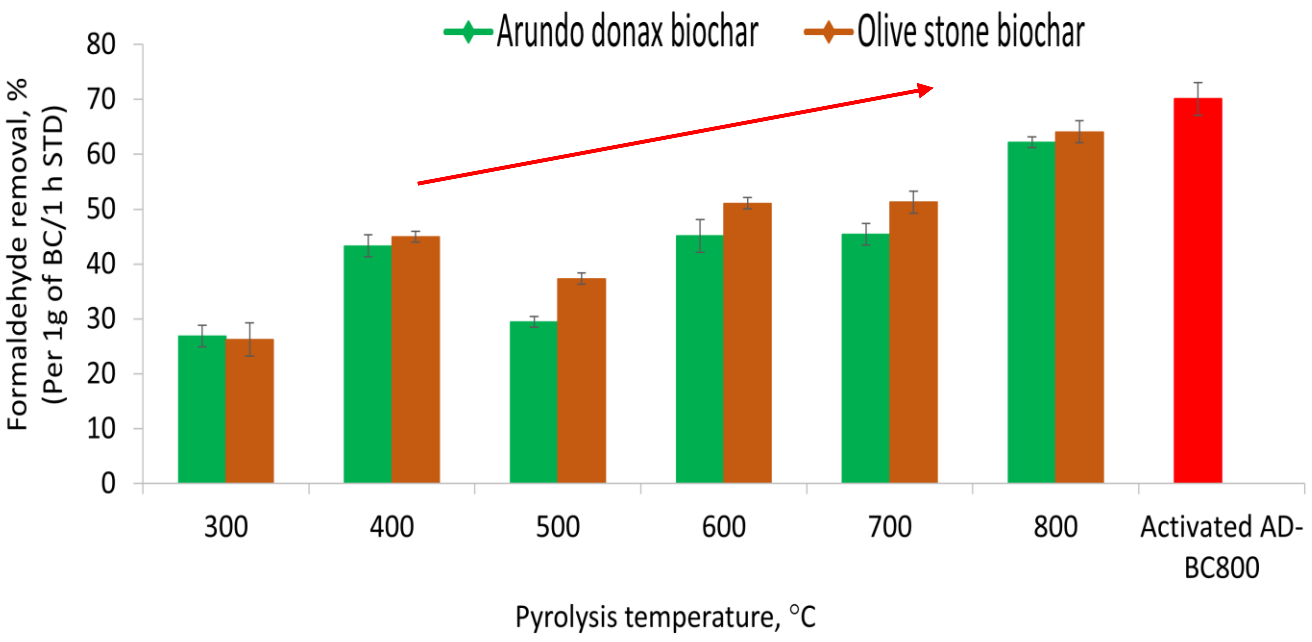
Effect of pyrolitic temperature on Porosity





- Higher pyrolysis temperatures favored the thermal degradation => more volatiles were released and created cavities and pores in the biochar.
- Larger porosity and microporosity.
- The activation increased the SA by 43%.
- The activation increased the microSA by 14%.

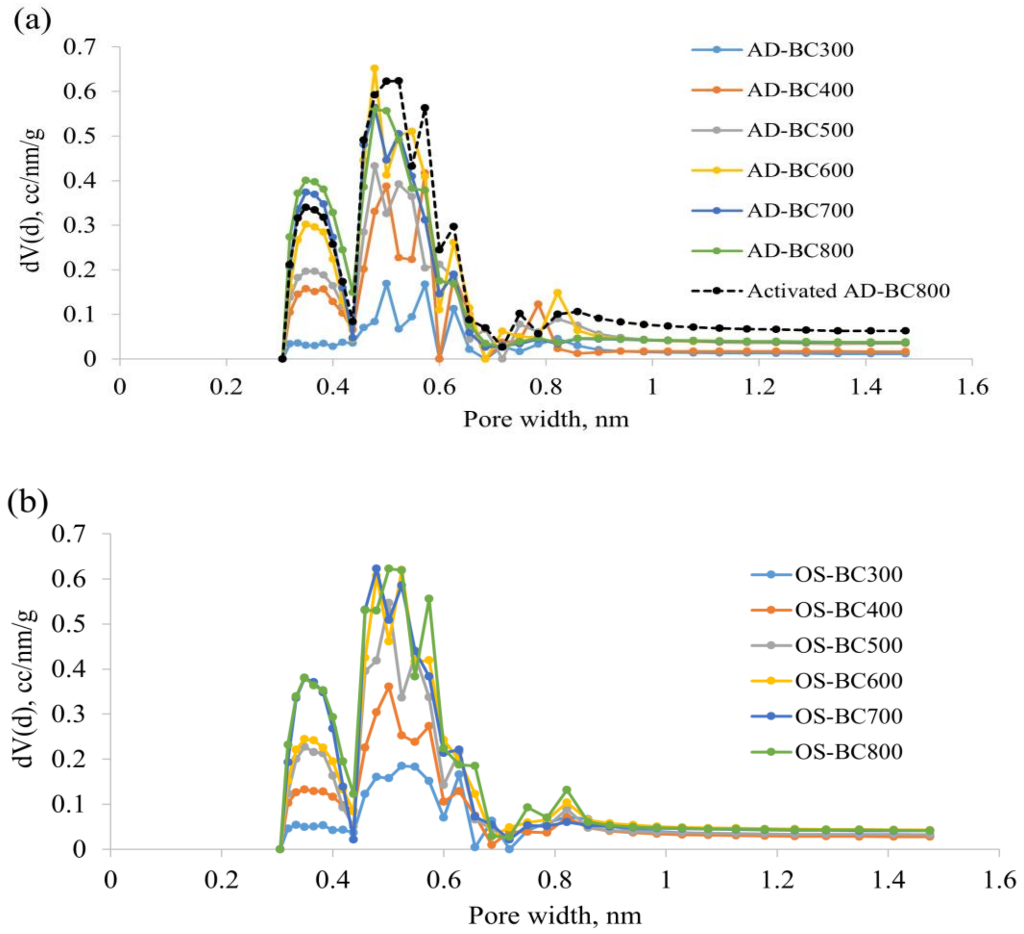
Formaldehyde removal efficiency



- Positive correlation between FA removal and SA, Micro SA, and carbon content
- Multiple regression: only microporous SA had significant influence
- Occurrence of micropores in the was the key parameter for efficient formaldehyde removal

- Biochar prepared at higher temperature exhibited the highest adsorption efficiency=> porosity
- Type of biomass didn't influence the performance of biochar in removing formaldehyde

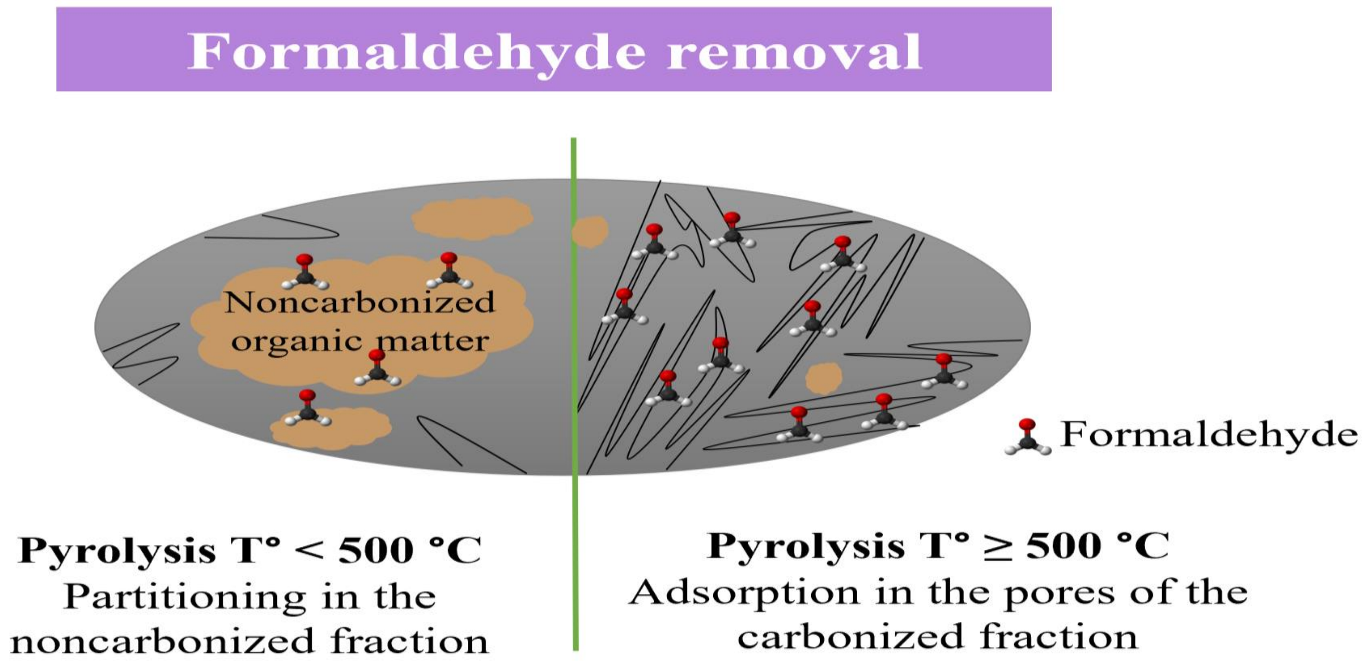
Formaldehyde removal efficiency



0.3 nm 0.8 nm

- Small size of the formaldehyde molecule, 0.25 nm was likely favorable for filling narrow micropores
- Relation between adsorption capacity, pore size, and adsorbate size

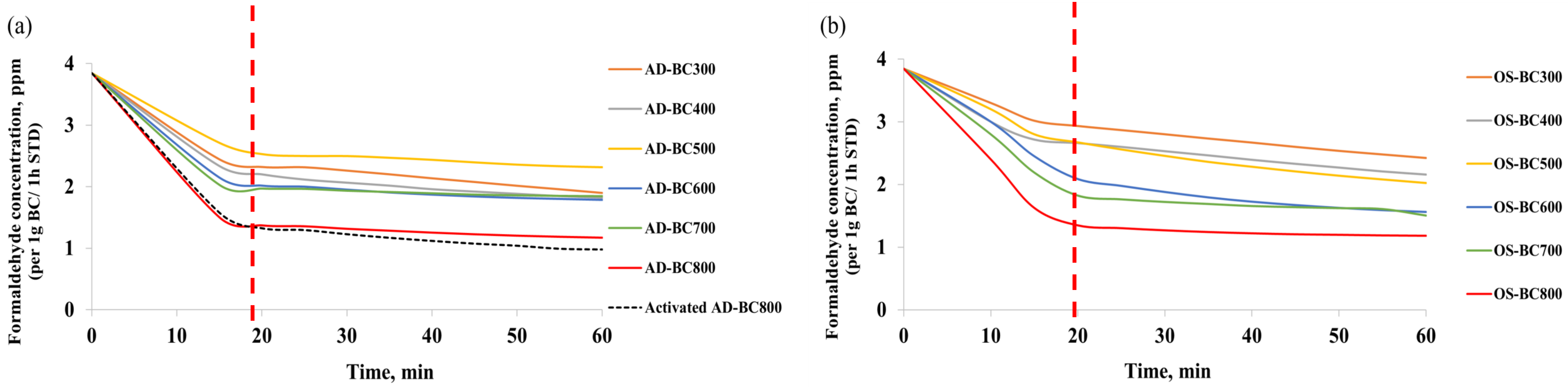
Formaldehyde removal mechanism



- Interaction with formaldehyde molecules via **polar and non-polar interactions**
- FA diffused into the **amorphous structure**

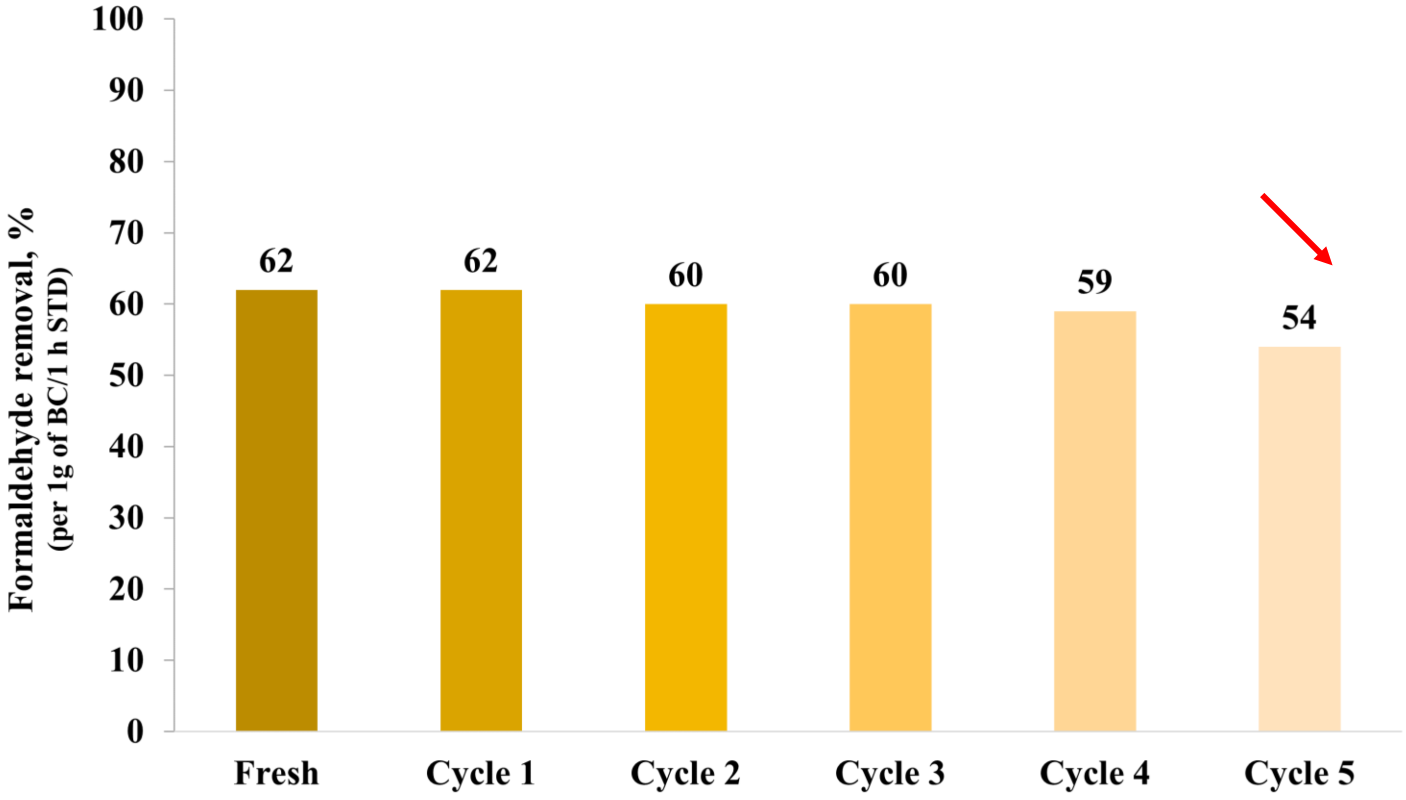
- Physical adsorption
- Assisted by the developed porous structure and large surface area: **pores filling**

Formaldehyde removal in function of time



Equilibrium was reached after 20min => saturation of the biochar

Reusability test



- Thermal regeneration in the oven for 1h at 80°C
- At the 5th cycle the adsorption capacity dropped by 13%
- Structural changes caused by several thermal regenerations

Conclusion and perspectives

- Biochar form olive stone and *Arundo donax* was successfully used for capturing formaldehyde.
- Limitation: Saturation of biochar pores

- Future research: Doping biochar with **active photocatalysts** to enable continuous formaldehyde removal through **integrated adsorption-photocatalytic degradation technology**.

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Thank you for your Attention.