BBioNets

Boosting the adoption of Bio-Based Technologies

Cross-Fertilisation Meetings

Bio-Based Practices on Farms & Forests

"Innovations in Nutrient Recovery"

Use of biochar and its principal benefits for soil health

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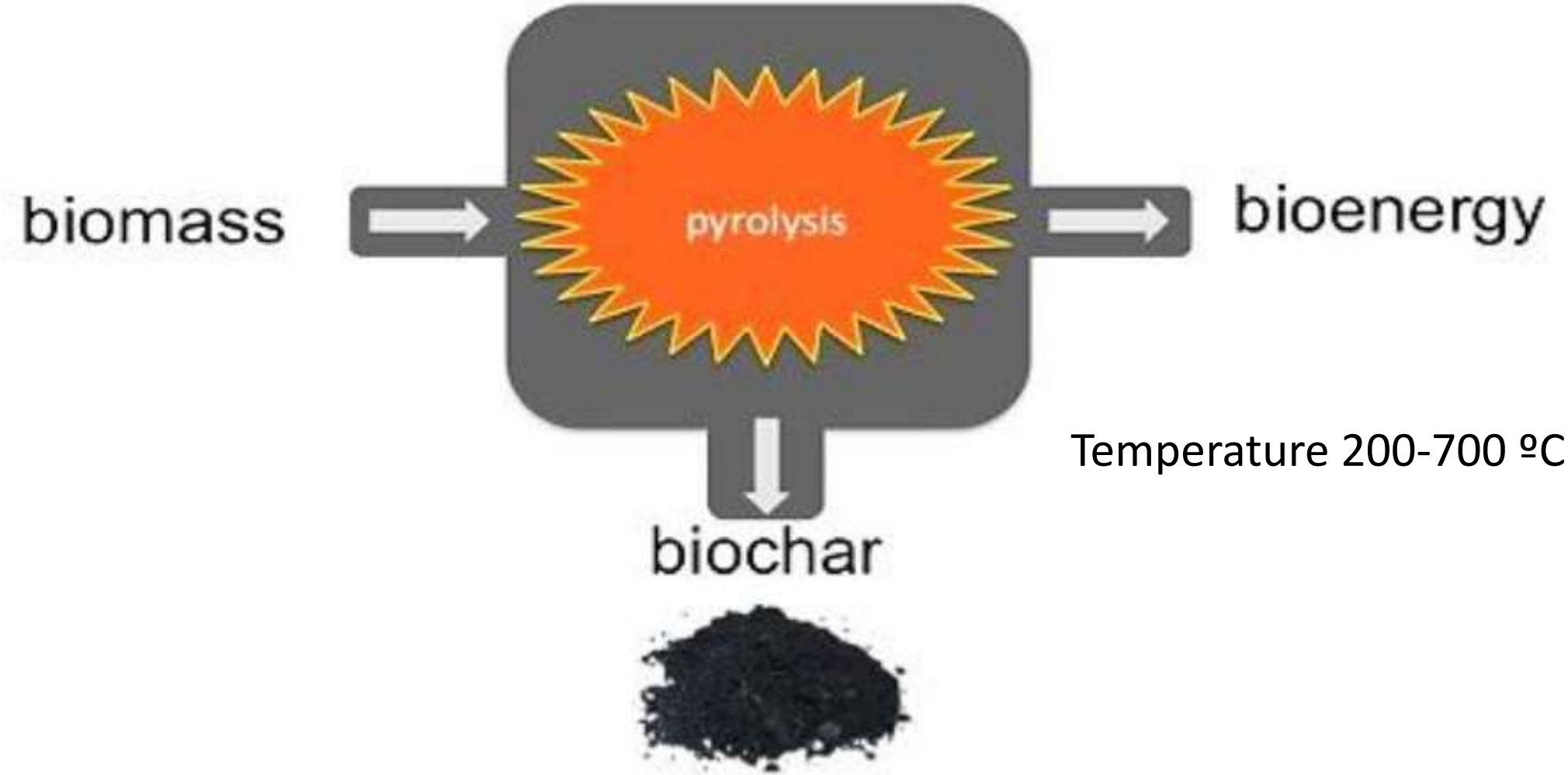
BBioNets

What’s BIOCHAR?

- **Biochar is the name given to plant-based charcoal when it is used as a soil amendment. It is plant-based biomass processed through pyrolysis.**

How is it made?



Temperature 200-700 ºC

Pyrolisis

- Thermal decomposition of biomass components
- Temperature 280-500 °C and limited oxygen supply
- Breakdown of large molecules into smaller ones

Pyrolisis Products

- Solid: biochar (280-500 ° C)
- Liquid: tars, high molecular weight hydrocarbons and water
- Gas: CO, H_2O, H_2, CH_4

Energy production

Gasification

How do we made it?

Gasification plant

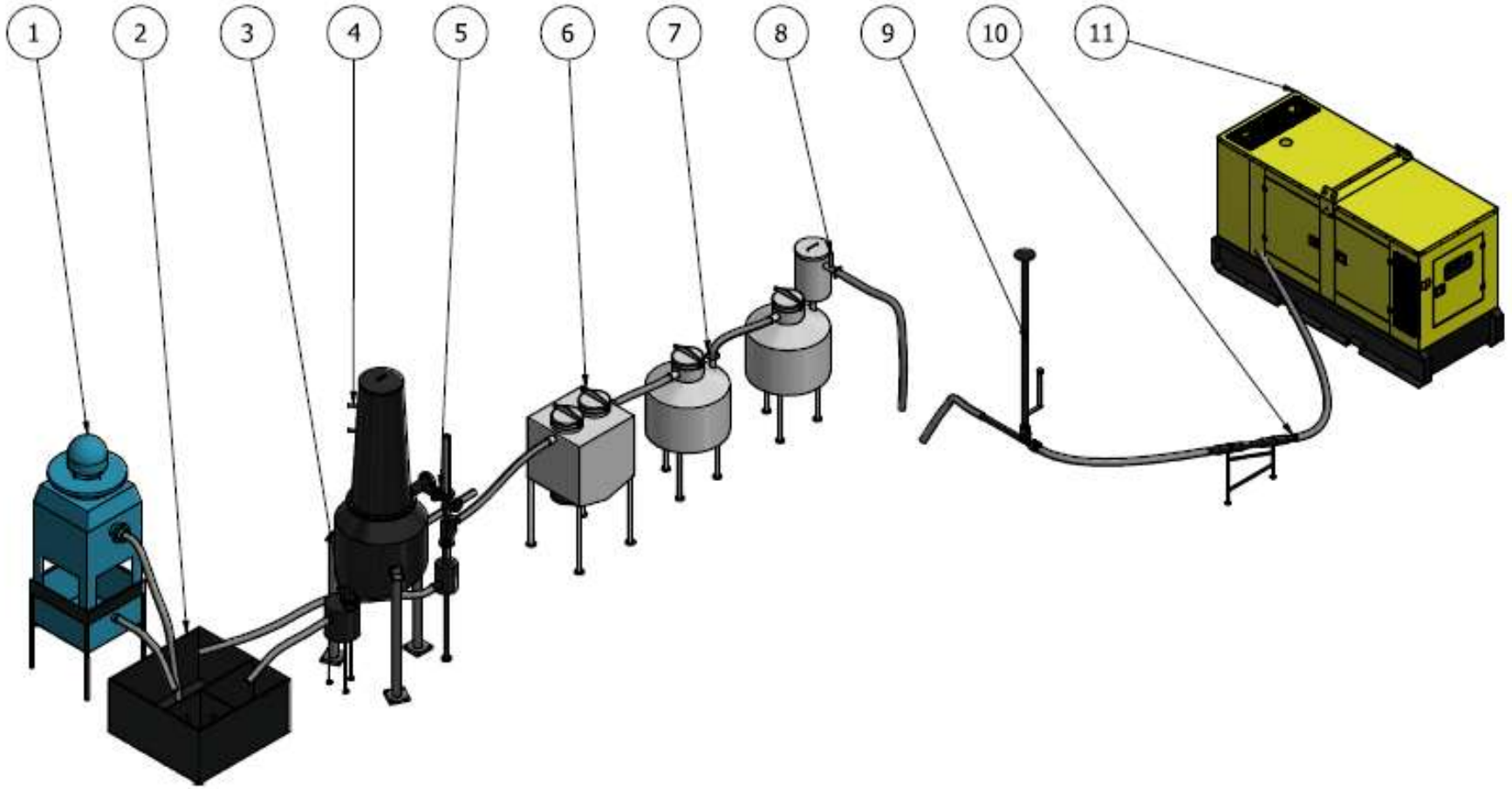
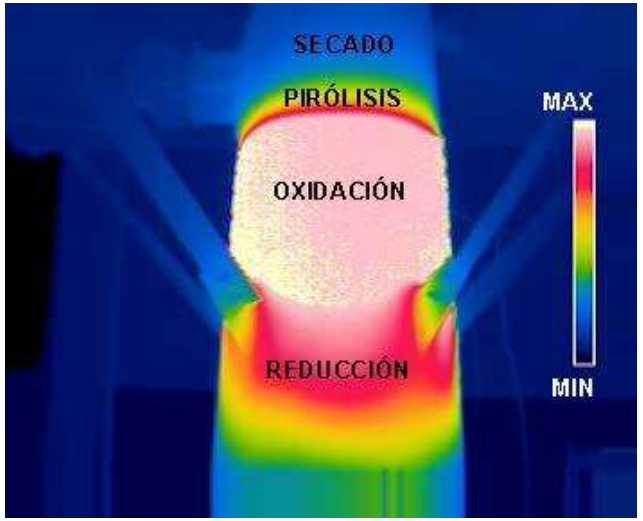


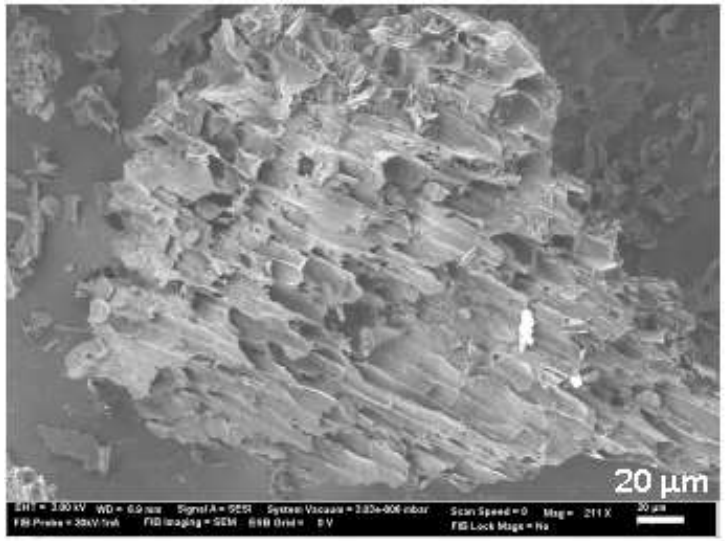
Fig. 2. 3D layout of the biomass gasification plant: ① cooling tower; ② water tank; ③ char removal unit; ④ downdraft fixed-bed gasifier; ⑤ wet scrubber; ⑥ coarse filter; ⑦ fine filters; ⑧ safety bag filter; ⑨ flare stack; ⑩ Venturi flow meter; ⑪ spark-ignition engine–generator set.

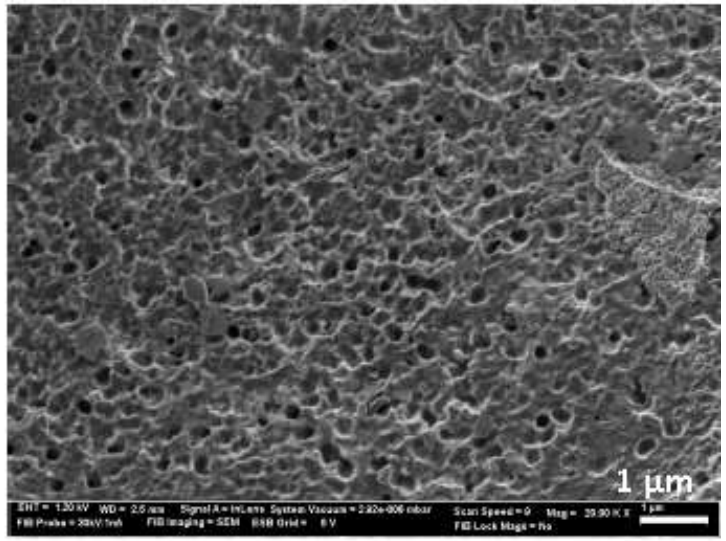
How does it work?

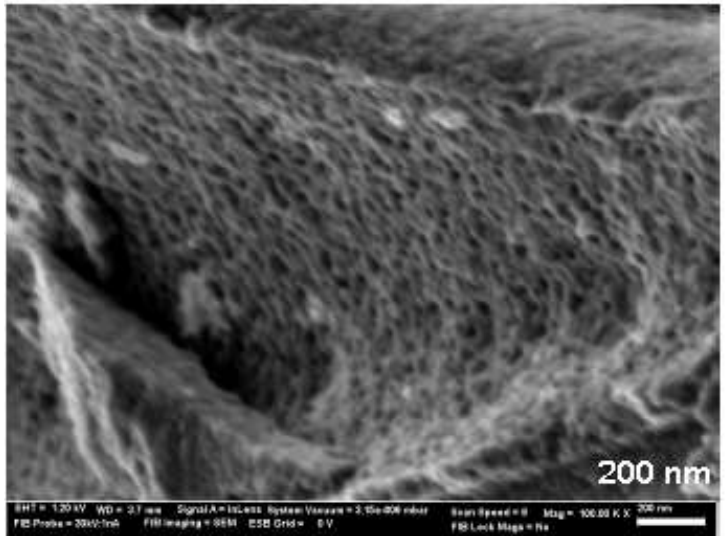


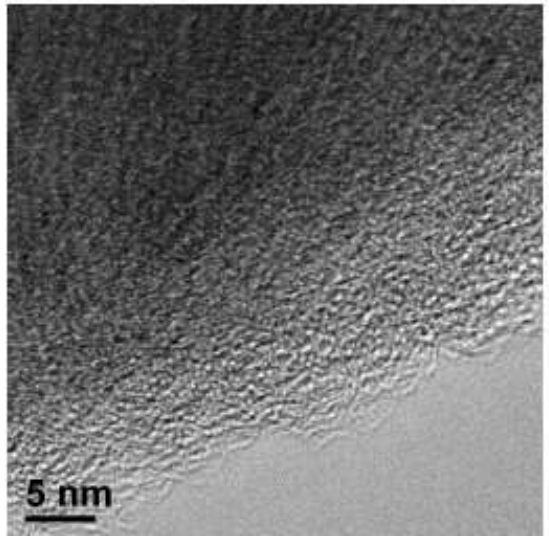
Biochar


14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33


20 µm

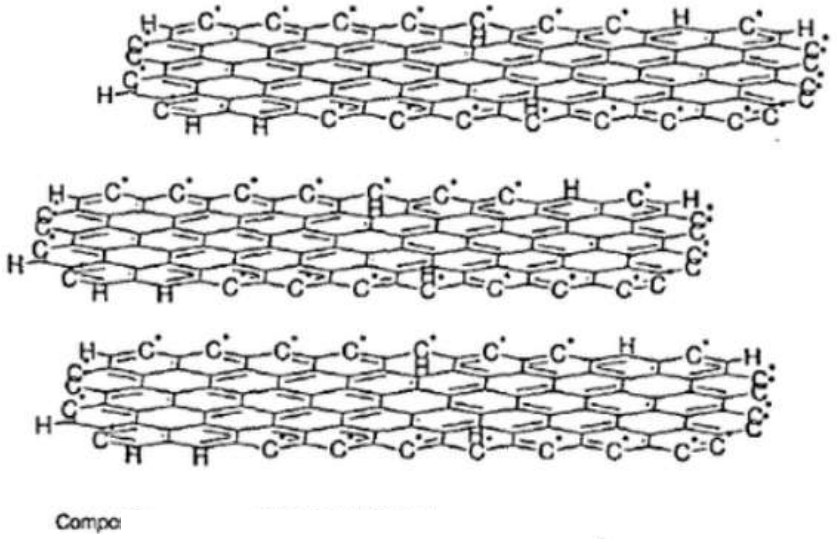

1 µm


200 nm

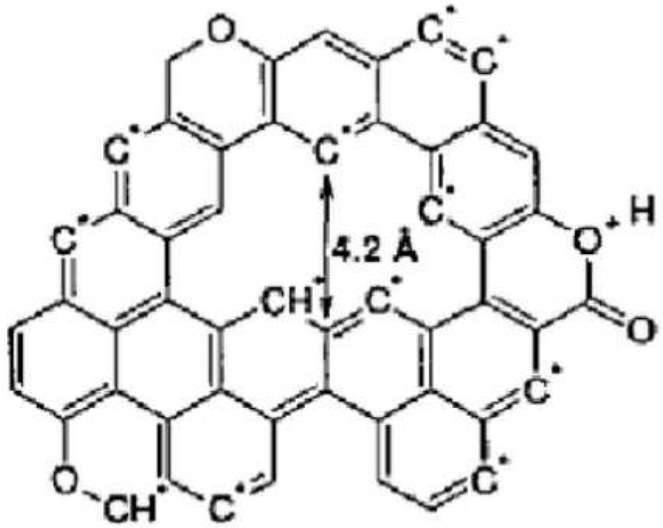

5 nm

Structural fractions of biochar

- Sheets of crystalline graphene

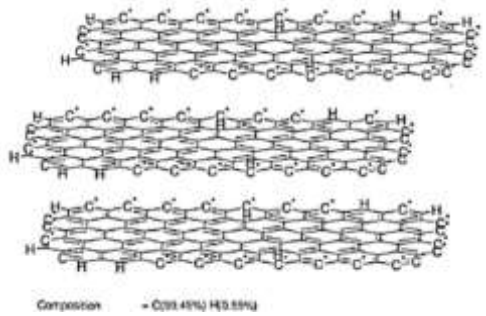


- Ordered amorphous aromatic structures



Associated carbon bonds (benzene rings with O or H)

Chemical structure

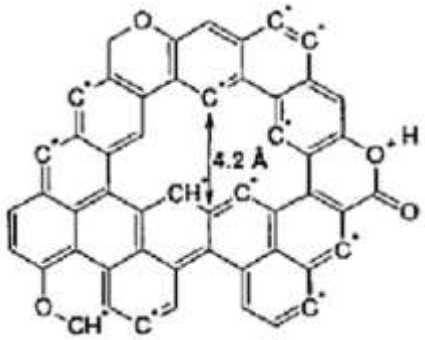


Highly recalcitrant

Resist chemical and biological oxidation

Residence time 10-10000 years

at least 10 to 10000 times longer residence time than soil organic matter



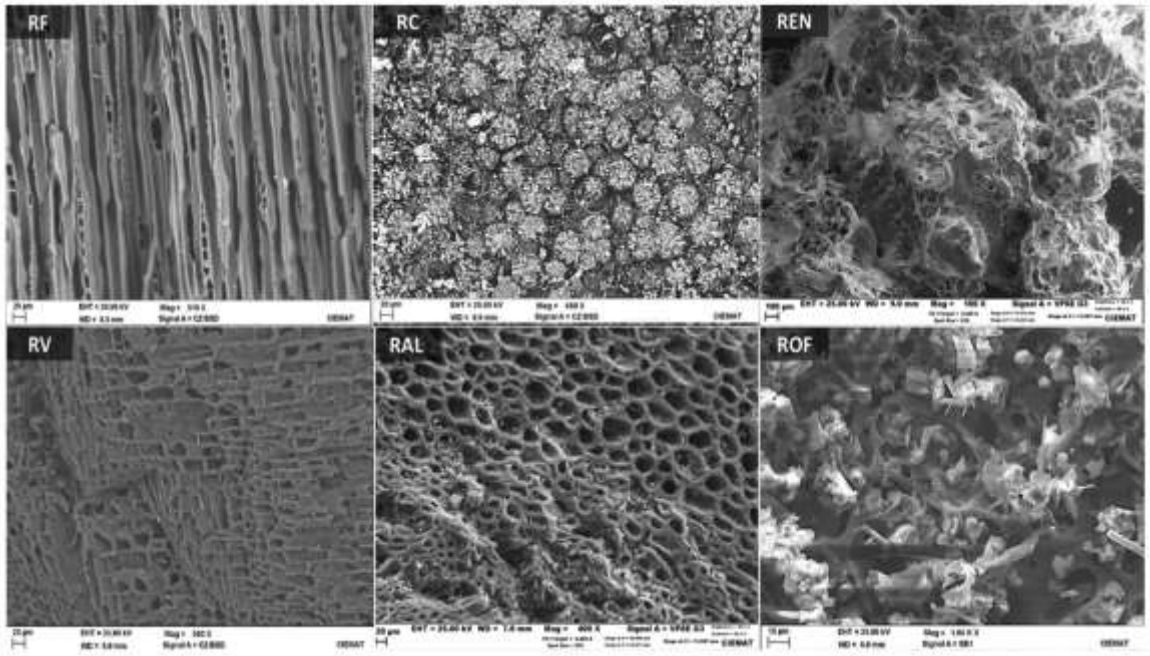
Oxidizable Fraction

Modifies the characteristics of the soil

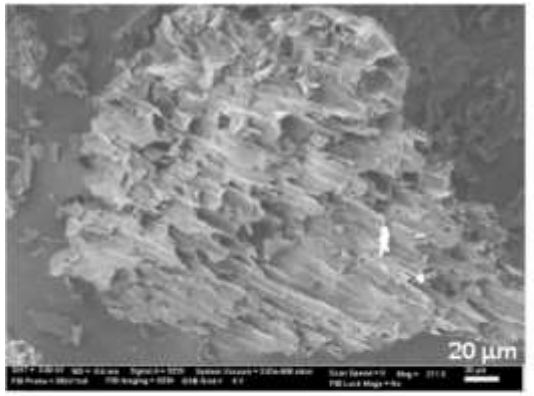
Physical and chemical properties

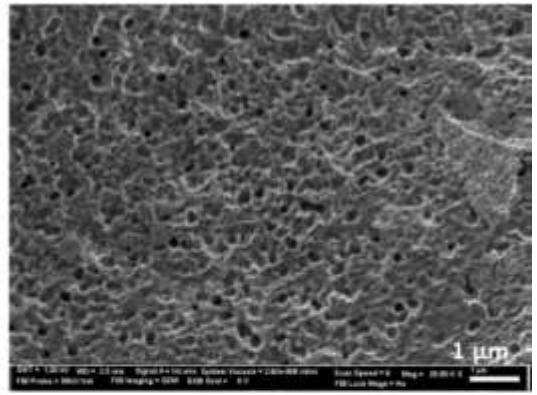
- Colour: Black
- Amorphous
- Particles different sizes
- Low aparent density
- High Surface area
- High porosity:
  - **Micropores** (< 2nm): **Adsorption of comp. liquids, solids, and gases**
  - **Mesopores** (2-50 mm)
  - **Macropores** (>50 mm): **Fast sorbate transport**

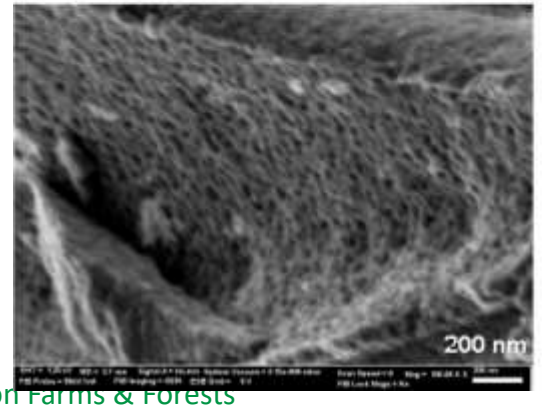
Porosity

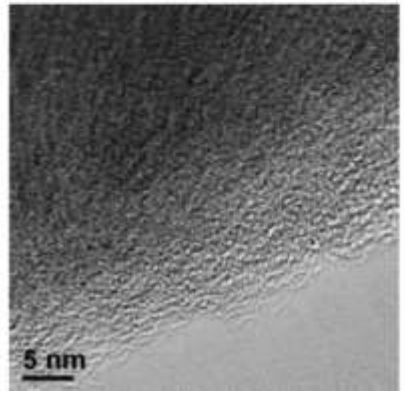


Ability to retain liquids, gases, or serve as a habitat for microorganisms depends on the porosity and type of pores.









The surface area of mesopores (50-2 nm) and micropores (< 2 nm) (Downie et al., 2009) can be related to the specific surface area (BET).

Physical and chemical properties

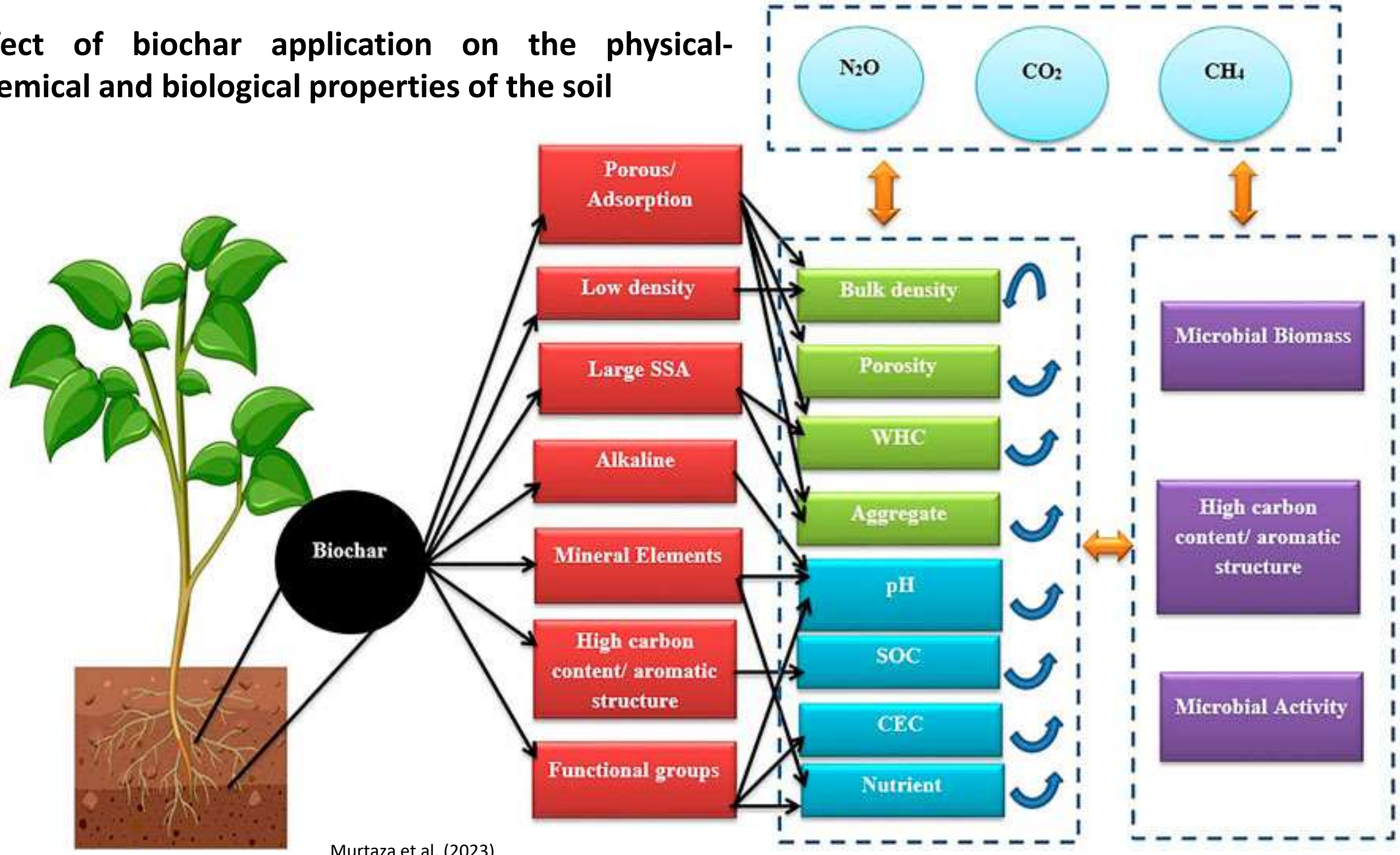
- Volatile fraction: precipitates in soil
- High C:N.
  - **Recalcitrance does not increase labile carbon.**
  - **The soil carbon-to-nitrogen ratio (C:N) does not increase.**
  - **It does not affect nitrogen assimilation by the plant.**
- pH basic: 8,5-9,1
- Cation Exchange Capacity: increases with pH
- Electrical Conductivity: 13700 µS cm^{-1}
- Water Retention Capacity: **78 %**

Physical and chemical properties

Physicochemical properties of charcoal from gasification of exhausted olive pomace pellets.

Parameter	Value	Unit	Standard method
Moisture content	10.5 ± 0.1	wt.% as received	ISO 18134:2015
Ash content (550 ± 10 °C)	21.9 ± 0.1	wt.% dry basis	ISO 18122:2015
Carbon (C), total	69.5 ± 0.2	wt.% dry basis	ISO 16948:2015
Hydrogen (H), total	0.8 ± 0.1	wt.% dry basis	ISO 16948:2015
Nitrogen (N), total	1.54 ± 0.05	wt.% dry basis	ISO 16948:2015
Sulfur (S), total	0.34 ± 0.03	wt.% dry basis	ISO 16948:2015
Oxygen (O), total	5.9	wt.% dry basis	Calculated
H/C ratio	0.137	Molar dry basis	Calculated
O/C ratio	0.064	Molar dry basis	Calculated
Bulk density	363	kg/m^3	ISO 17828:2015
Specific surface area (BET)	199.7	m^2/g	ISO 9277:2009

Effect of biochar application on the physical-chemical and biological properties of the soil

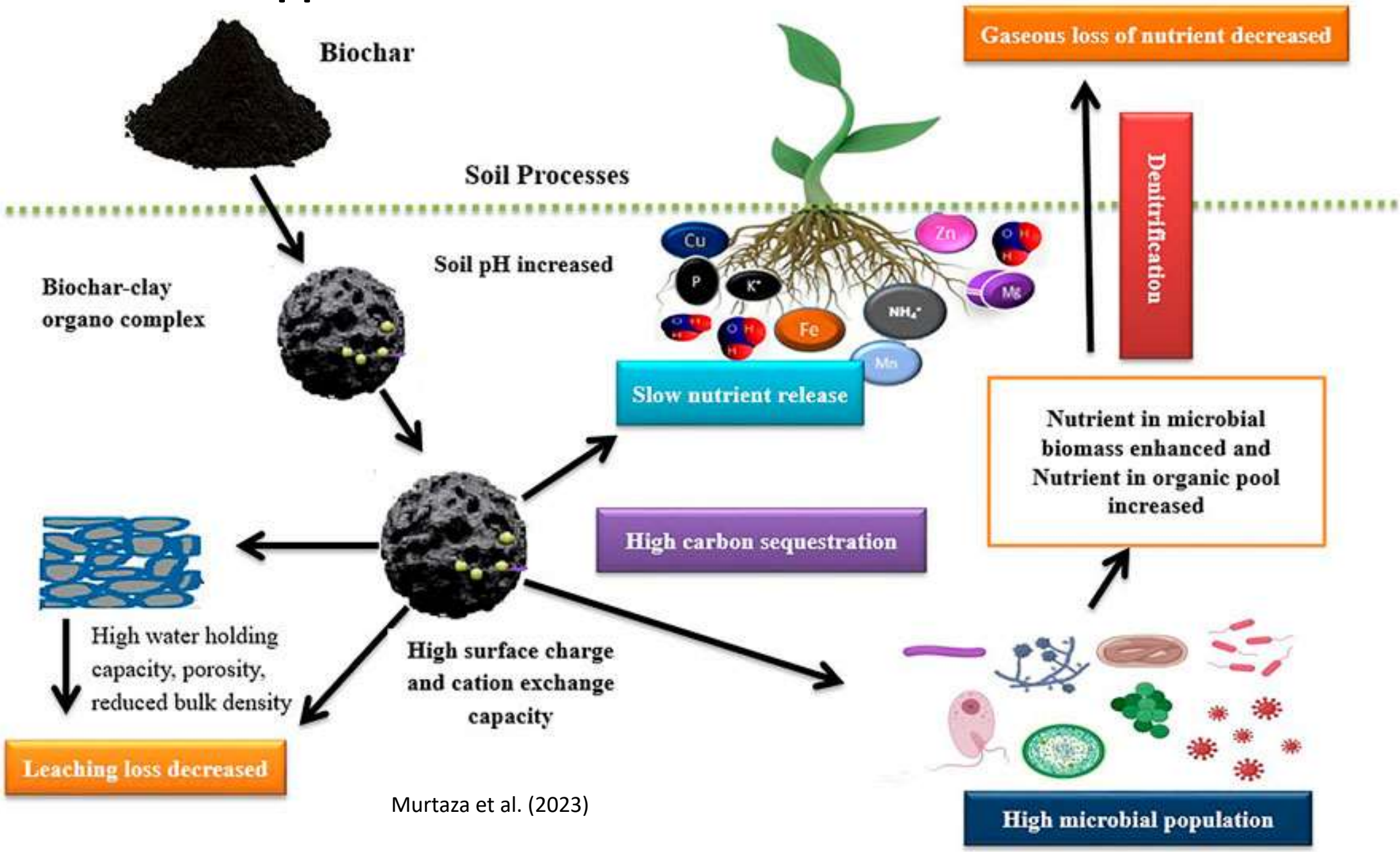


Murtaza et al. (2023)

Biochar

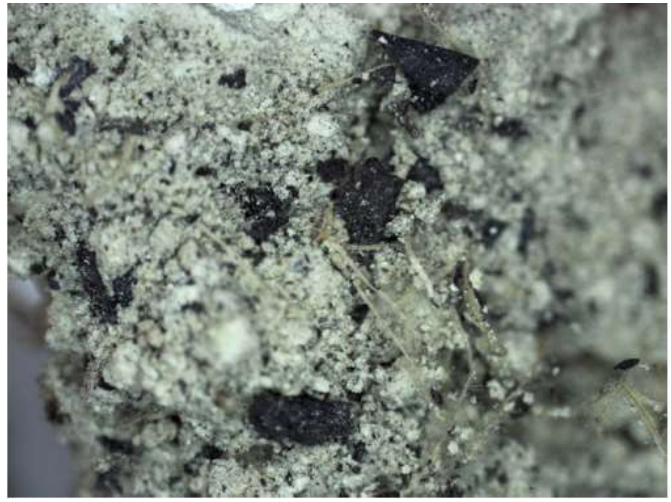
- CO2 SINK
- SOIL IMPROVEMENT
- WATER RETENTION CAPACITY
- PREVENTS EROSION AND LEACHATE
- IMPROVED CROP YIELDS
- BUSINESS OPPORTUNITY

Effect of the application on the soil



Murtaza et al. (2023)

Soil Physical changes

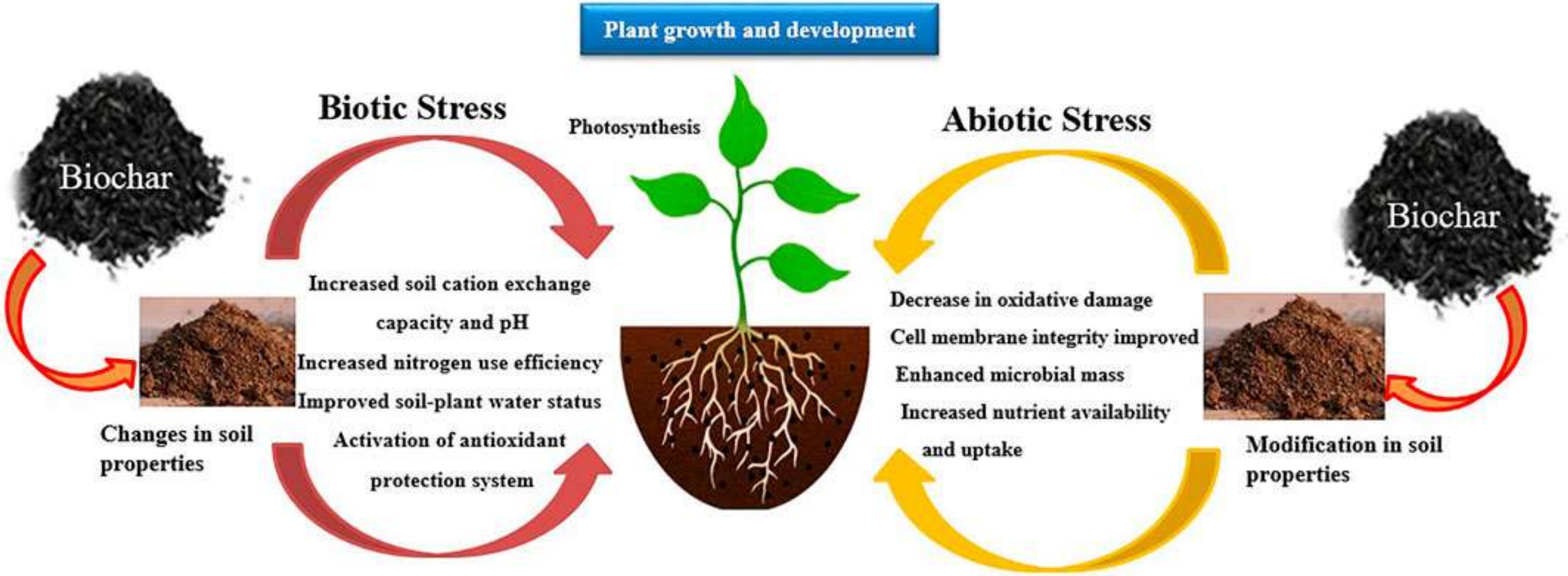


- Reduction of soil density, biochar has a low density.
- Increase of soil porosity by 5-25 µm (depending on the raw material).
- Reduction of soil compaction, tillage is not necessary.
- Prevention of erosion and leaching.

Soil Physical changes

- Promotes the formation of soil aggregates, especially in sandy soils, allowing them to store more water.
- Reduces compaction in clay soils, facilitating water movement.
- Increases soil field capacity and lowers the wilting point, thus increasing the amount of water available for crops.

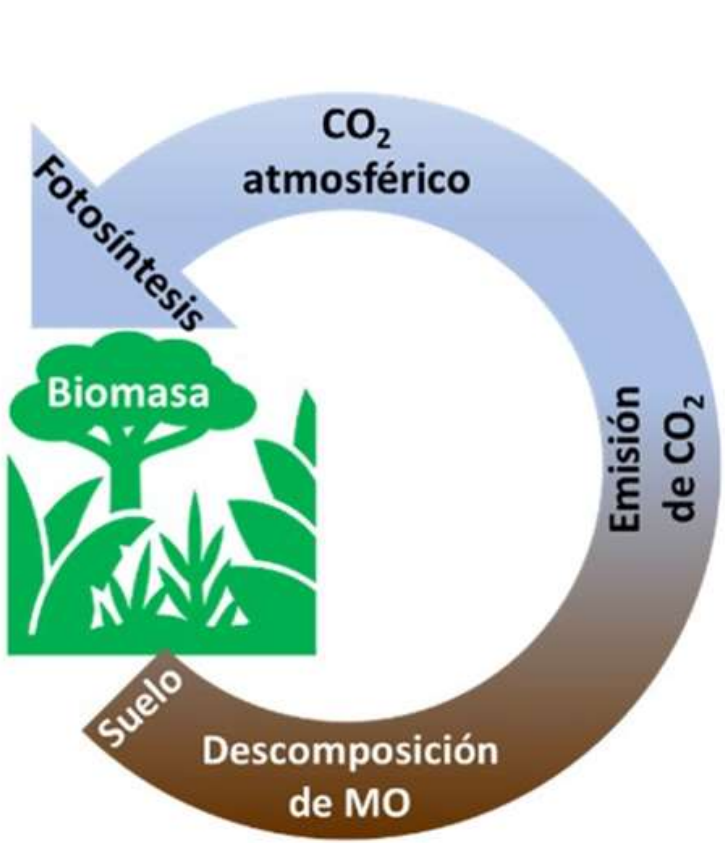
Improving plant resilience to biotic and abiotic stress

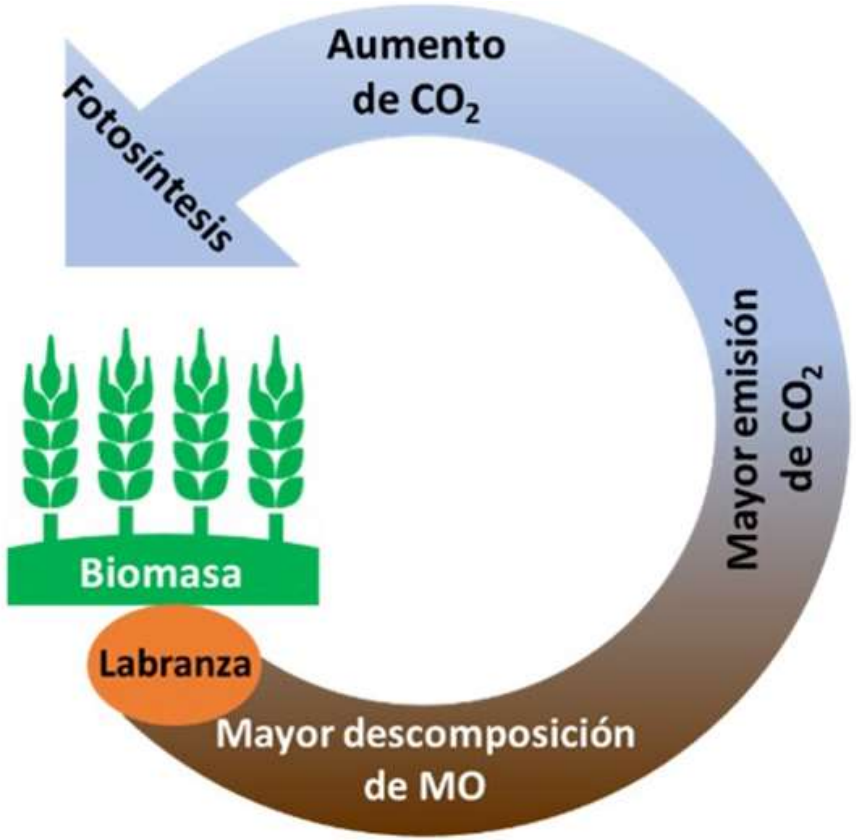


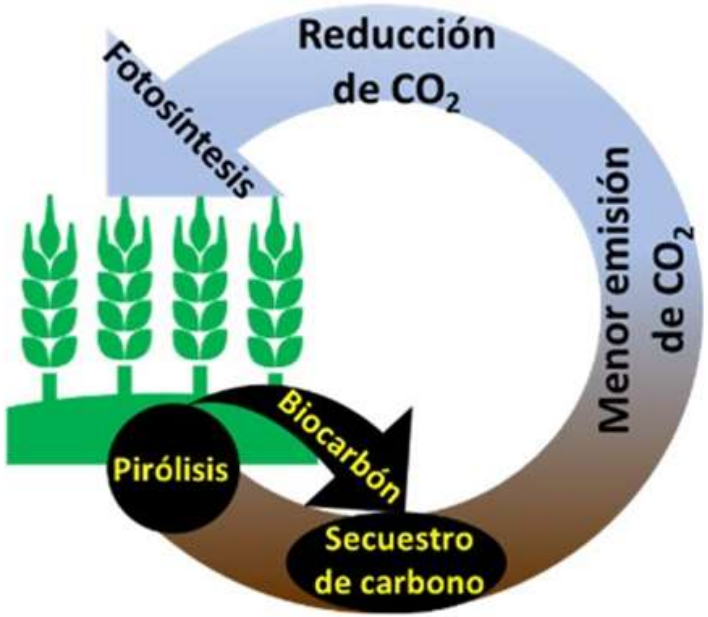
Resistance to biotic and abiotic stress

- ❑ Reduces plant diseases (85% of published studies)
- ❑ Improves seed germination
- ❑ Mitigates the response to saline stress
- ❑ Improves the response to water stress
- ❑ Adsorbs heavy metals in contaminated soils

Biochar: Carbon fixation



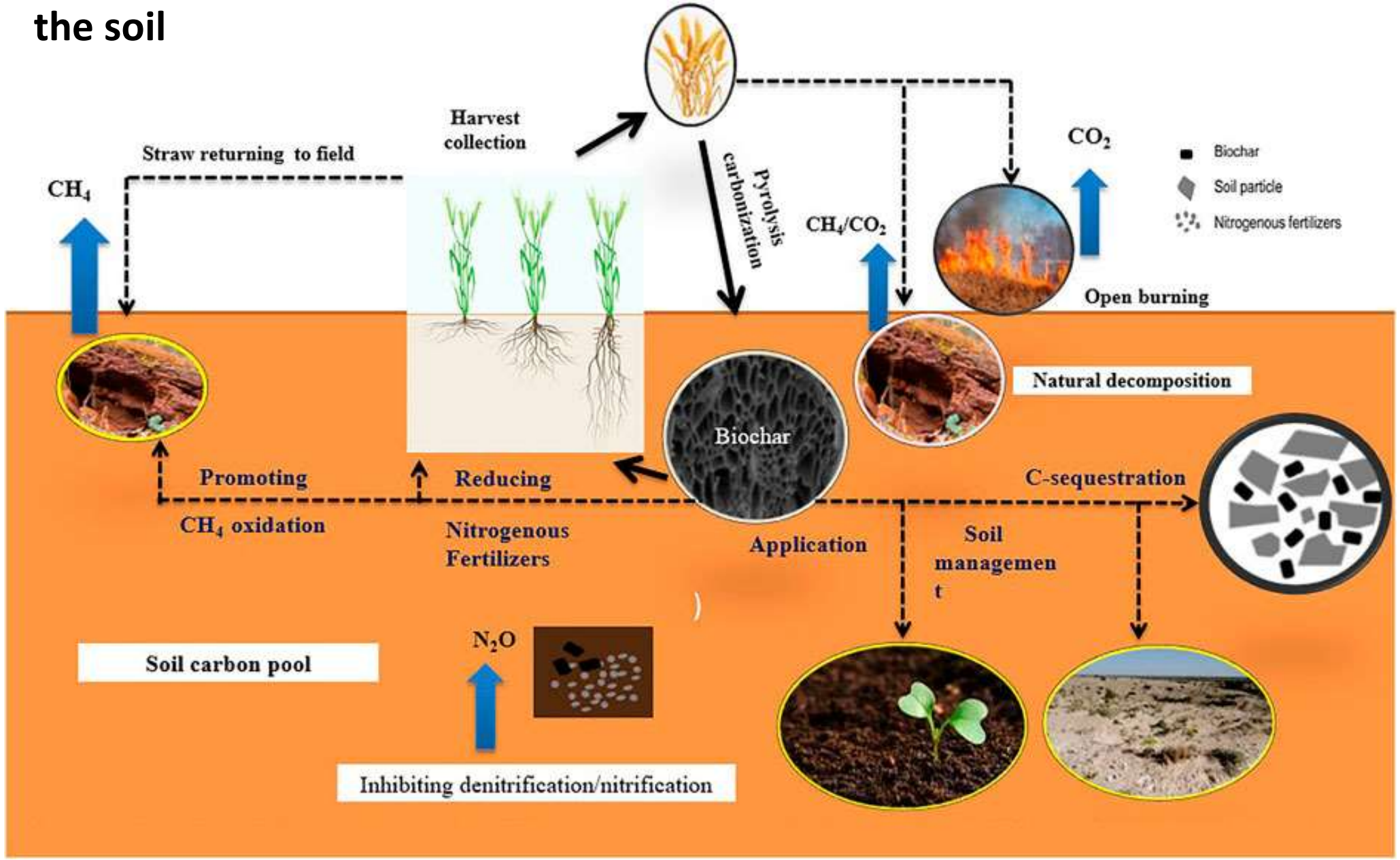




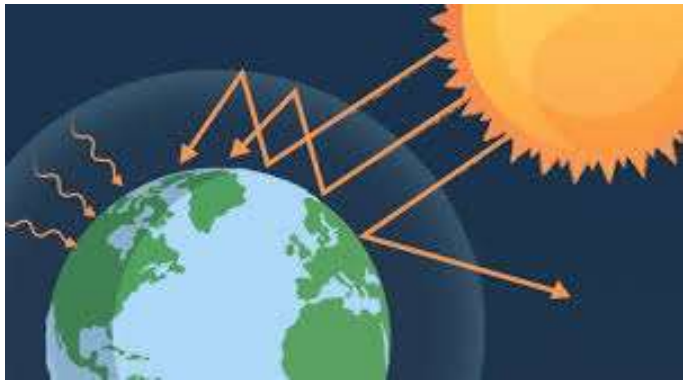
1 kg Biochar ⟶ 2,8 kg CO2 captured

⟶ 50 €/tnCO2

Mechanism for reducing greenhouse gases (GHG) and sequestering carbon in the soil

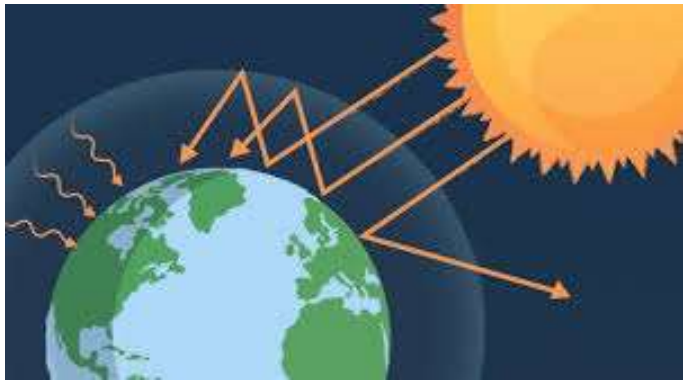


Effect on greenhouse gases



- Reduction of CH_4 production in soils through the addition of biochar.
- Biochar promotes CH_4 oxidation in the soil.
- Reduction of nitrous oxide (N_2O) emissions due to the stability generated during the pyrolysis stage and the physicochemical properties that biochar imparts to the soil (Woolf et al., 2012).

Effect on greenhouse gases



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Conclusions

- ❑ Increases crop production and yield
- ❑ Improves the soil's physical and chemical characteristics
- ❑ Enhances soil microbiota
- ❑ Protects against erosion and leaching
- ❑ Increases water retention
- ❑ Improves plant response to biotic and abiotic stresses
- ❑ Adsorbs heavy metals in contaminated soils
- ❑ High carbon sequestration capacity and greenhouse gas mitigation

Thank you!

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