# Biochar from gasification in cultivated soils and riparian buffer zones: Chemical characterization

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# BIOCHAR FROM GASIFICATION IN CULTIVATED SOILS AND RIPARIAN BUFFER ZONES: CHEMICAL CHARACTERIZATION

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During rain events, pollutants in agricultural soils can be transported from fields to surface and/or groundwater resulting in contamination of streams and rivers.

Researchers and farmers should work together to find solutions to ensure the preservation of crop production without modifying water quality or the health of ecosystem.

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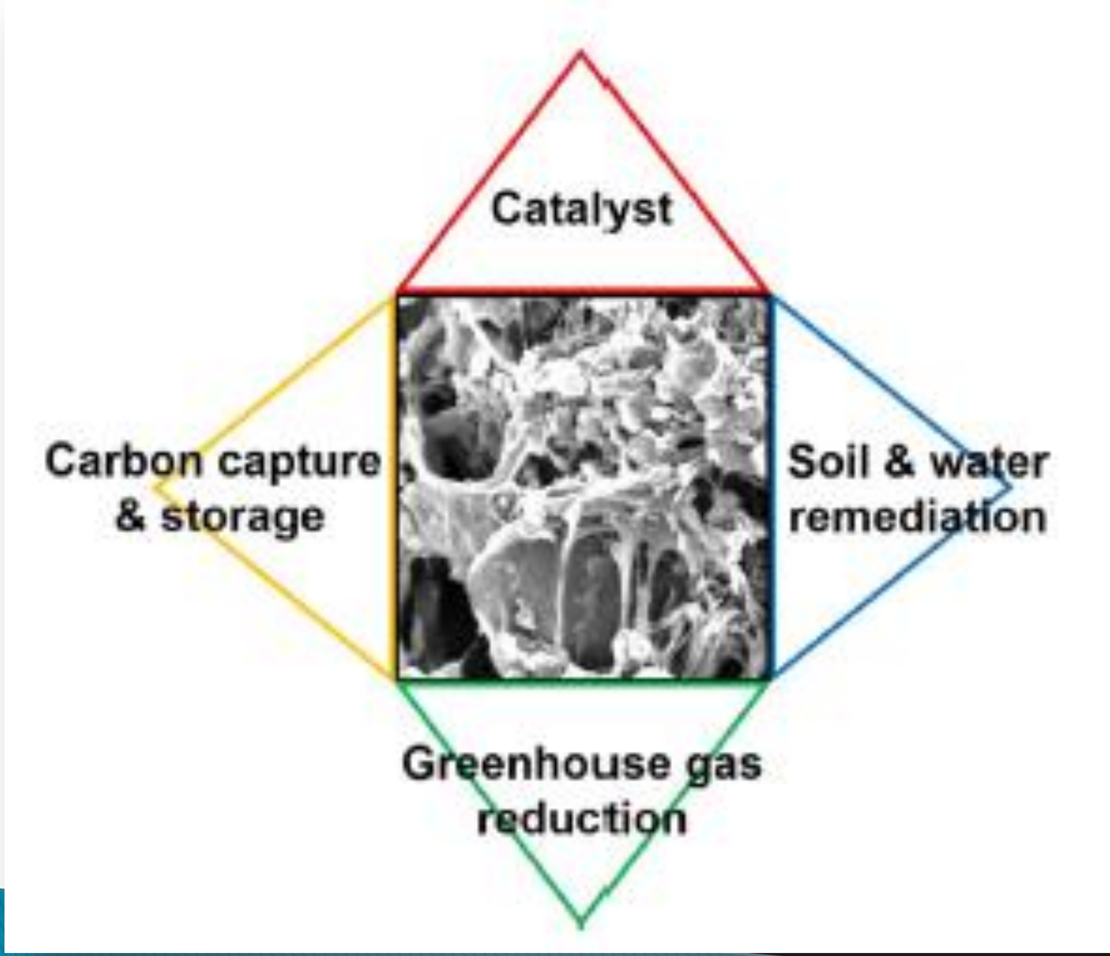
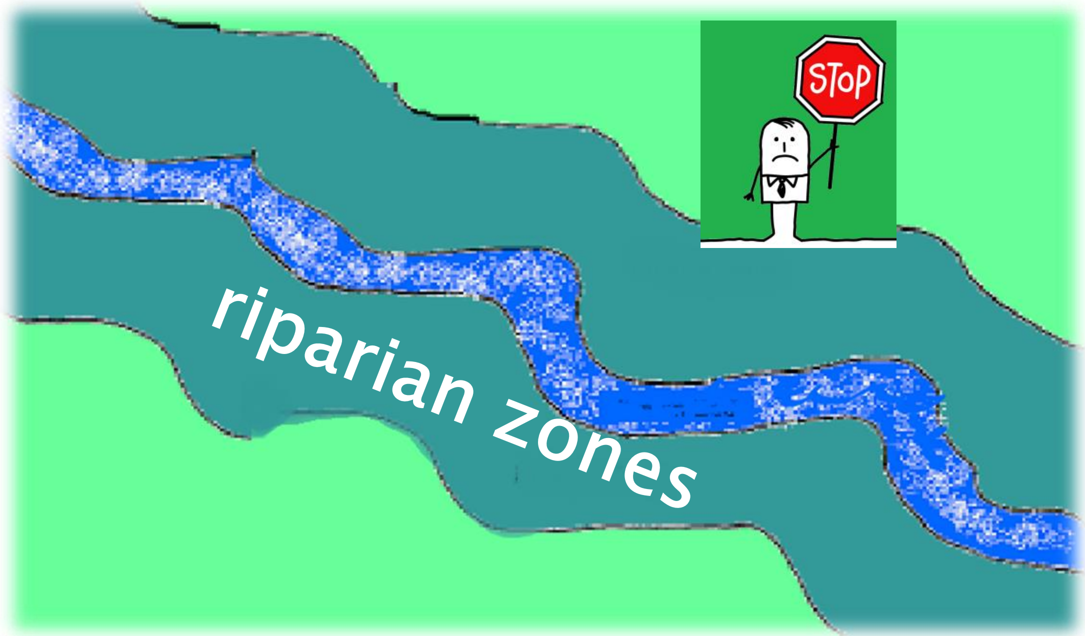
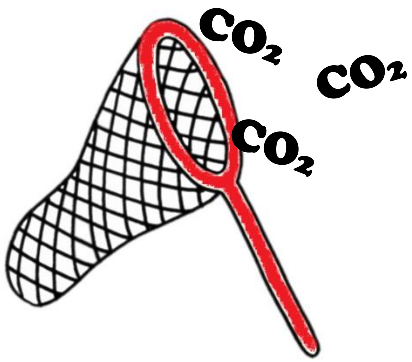
# Versatility of Biochar




Renewable and Sustainable Energy Reviews 77 (2017) 70-79

**The addition of biochar to soils, particularly in a riparian zone, can reduce the mobility of contaminants**




**...., biochar can concur to climate change mitigation by sequestering soil organic carbon into a form that is more resistant to mineralization than fresh biomass.**

# Research Projects:

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**Carbonization of Agricultural Residues: Biochar Precious Solution for Carbon Sequestration in Soil.**
*(Carbonizzazine dei residui agricoli: Biochar preziosa Soluzione per il Sequestro di Carbonio nel Suolo.*)
PSR misura 16 Focus Area 5E Regione Emilia Romagna.

**The use of biochar as a biological filter for water purification: the Soil amendment that clean the environment**
*Uso del Biochar come filtro biologico per la depurazione delle acque: l'ammendante che depura l'ambiente*
"PSR misura 16 Focus Area 4B Regione Emilia Romagna.

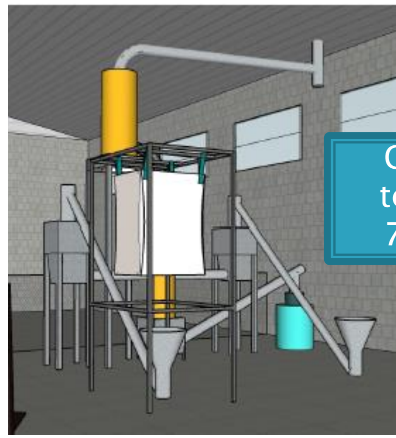
# Circular use of biomasses

Energy

100 kWh

Biochar
To enhance soil properties

up-draft gasifier operating under direct burning of tar and syngas



Gasification temperature 700-800 C°


Biochar was synthesized from commercial wood pellet as reference biomass

Patent WO 215/018742

- Pruning scraps coming from riparian zone management
- Agricultural Waste

# Aim

Determination of the quality of biochar obtained from an innovative gasifier prototype

Assessment of pollutant immobilisation capability of biochar

Determination of biochar concentration in soil

## Chemical Biological parameters

| | | | |
|---|---|---|---|
| **TOC** | % C | > 60 | **79%** |
| **Salinity** | mS/cm | ≤ 10 | **1,8** |
| **pH** (H2O) | | 4-12 | **10,1** |
| **Ash** | % | < 10 | **<5** |
| **H/C** (molar) | | ≤ 0.7 | **0,3** |

**Fitotoxicity:** **Suitable**

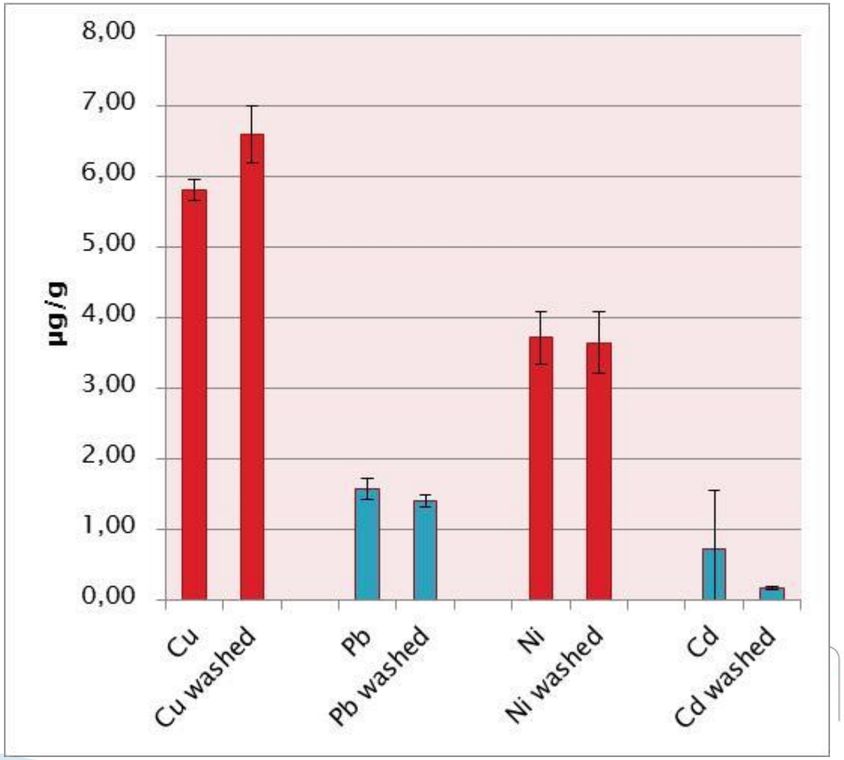
**Contaminants**

| | | | |
|---|---|---|---|
| Pb | mg/kg | ≤140 | **< 2** |
| Cd | mg/kg | ≤1.5 | **< 1.5** |
| Ni | mg/kg | ≤100 | **< 4** |
| Zn | mg/kg | ≤500 | < 4 |
| Cu | mg/kg | ≤230 | < 6 |
| Hg | mg/kg | ≤1,5 | nd |
| Cr(IV) | mg/kg | ≤0,5 | nd |
| PAH | mg/kg | <6 | **1,7** |
| PCB | mg/kg | <0.5 | nd |
| Dioxine | ng/kg | <9 | nd |

Annex 2 D.Lgs. n. 75/2010

**PSR is a biochar of high quality**

The analyzed metals are not water soluble (1.1 % solubilized)



# Elemental and Proximate analysis of PSR Biochar

## HCN (Thermo Fisher)

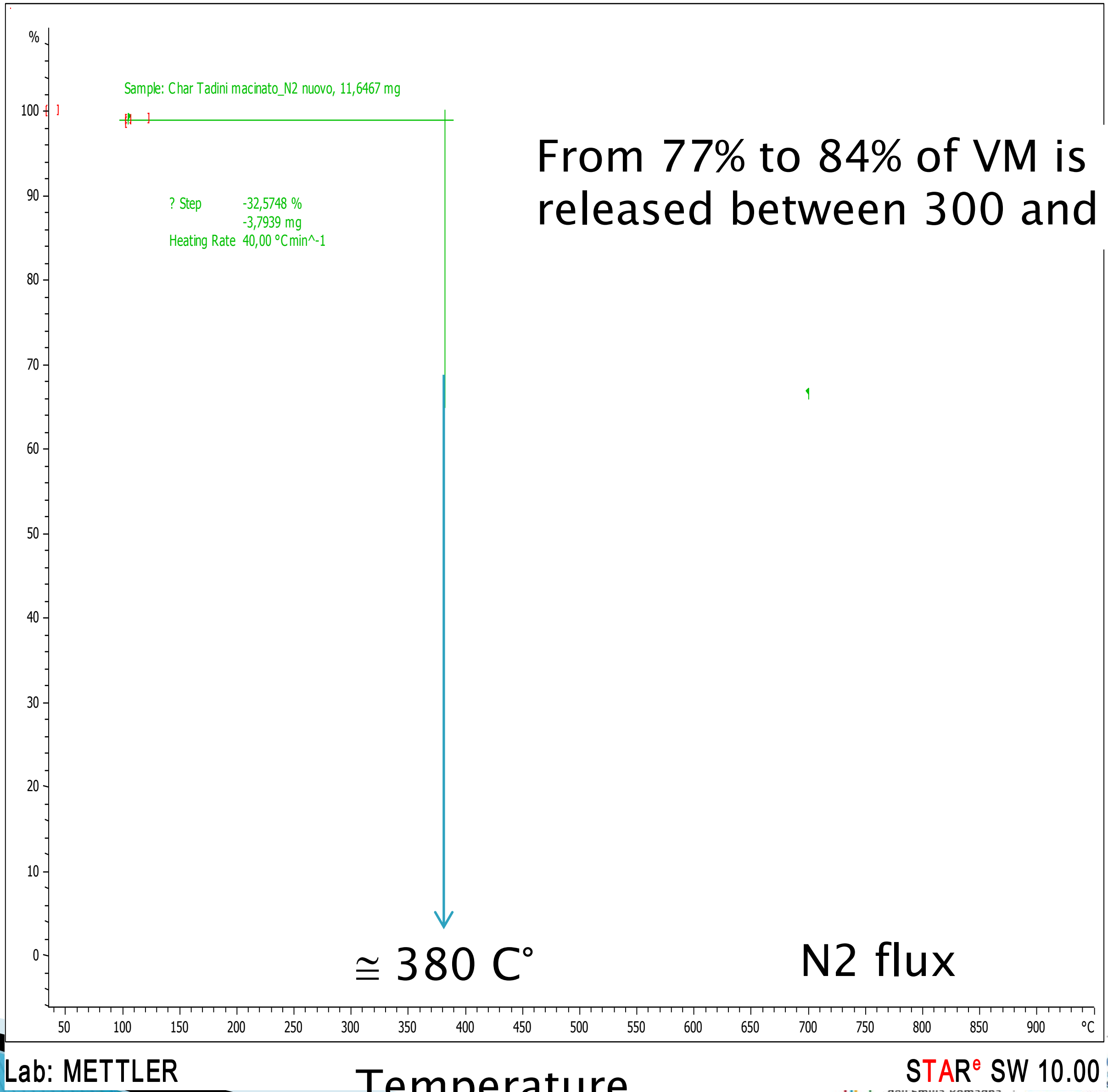
| | TC | TOC | N | H | H/C |
|---|---|---|---|---|---|
| | % (n=3) | | | | |
| **BIOCHAR** | **80** | **79** | **0,20** | **1,8** | **0,27** |
| DEV. ST | 4.7 | 2.1 | 0.05 | 0.12 | |

## Proximate analysis (TGA –Metler toledo) ASTM D7582 – 15

| | Moisture | Volatile | Fixed carbon | ASH |
|---|---|---|---|---|
| | (%) (n=4) | | | |
| **BIOCHAR** | **1,2** | **32** | **62** | **4,7** |
| DEV. ST | 0,1 | 6,7 | 6,5 | 0,3 |

| | Density | Conductivity EN 13038 | pH EN 13037 |
|---|---|---|---|
| **BIOCHAR** | 0,4 kg/L | 1,8 mS/cm | 10,1 |

# Further Thermogram information

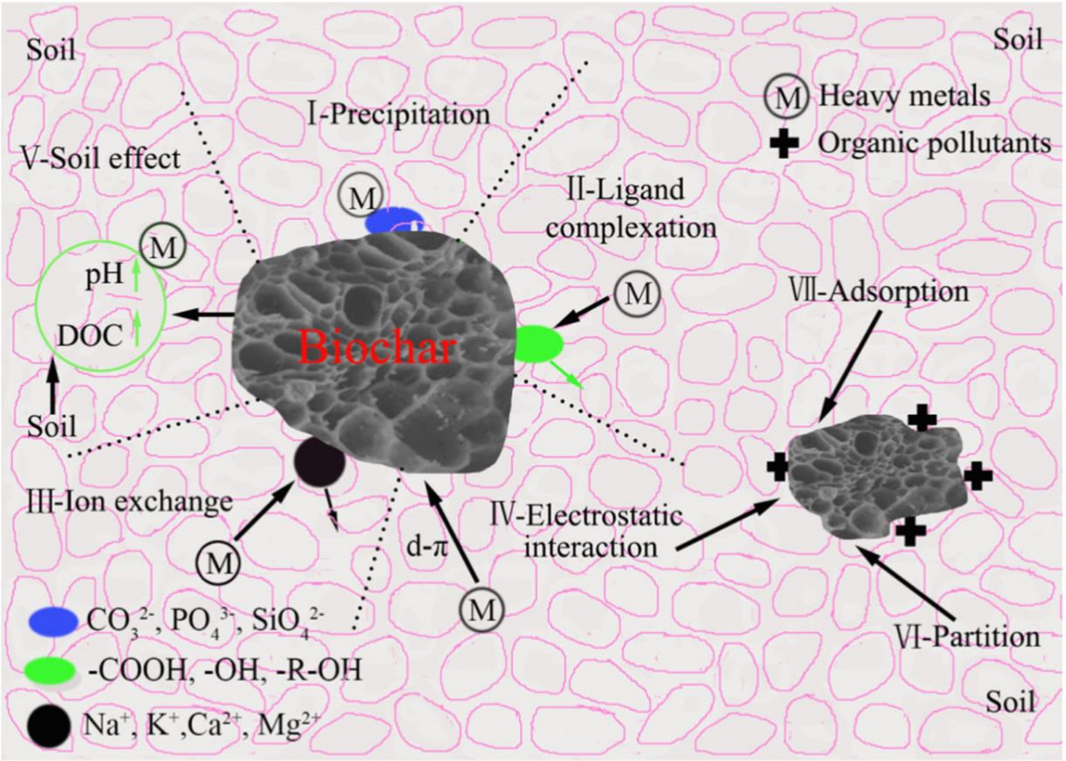



From 77% to 84% of VM is released between 300 and 700 C°

Loss of Weight

Temperature

# Sorption capacity determination




1. electrostatic interactions between metal cations and negatively charged biochar or soil surfaces
2. ligand complexation involving functional groups of biochar in the surface
3. cation exchange with $Na^+$, $Ca^{2+}$, $Mg^{2+}$, $Al^{3+}$, and other cations associated with biochar
4. precipitation or co-precipitation with the formation of oxides, hydroxides, phosphates, carbonates, silicates, and chlorates
5. Sorptive interactions between d-electrons of metals and delocalized π-electrons of biochar
6. increased soil DOC and pH by biochar

Environ Sci Pollut Res (2017) 24:16560-16577 - Shaohua Wu et al

# Sorption capacity determination: Sorption Isotherm curves

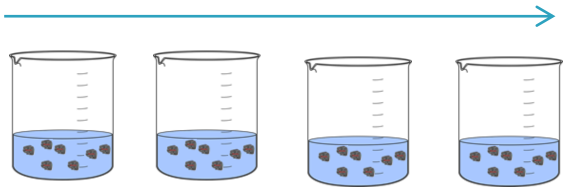
Sorption Isotherm curve of Biochar provides information about the relative sorption capacity


Partition

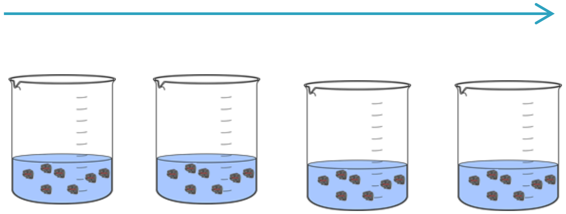
Water Solution

$Cd^{++}$

**Sorbate** concentartion



**Sorbent** concentartion



**Target metal: Cd**

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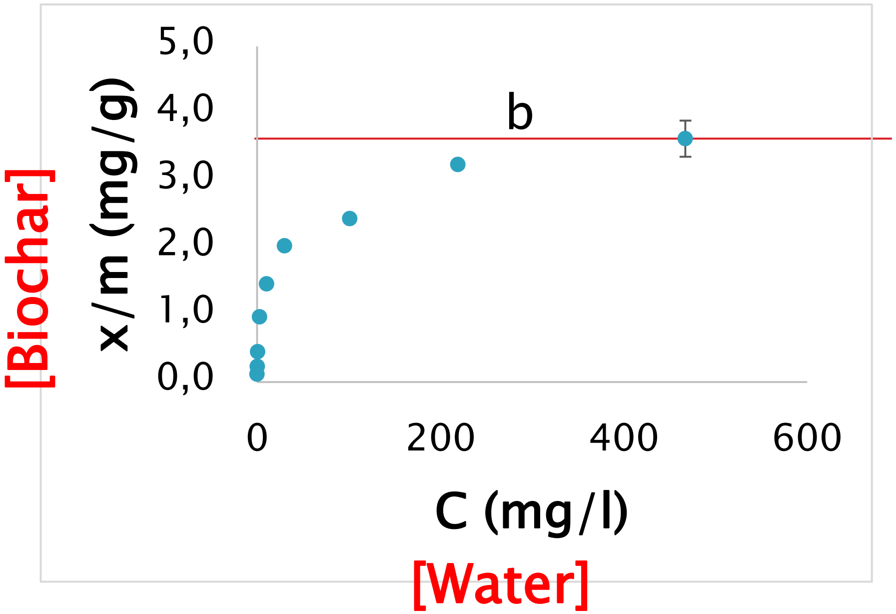
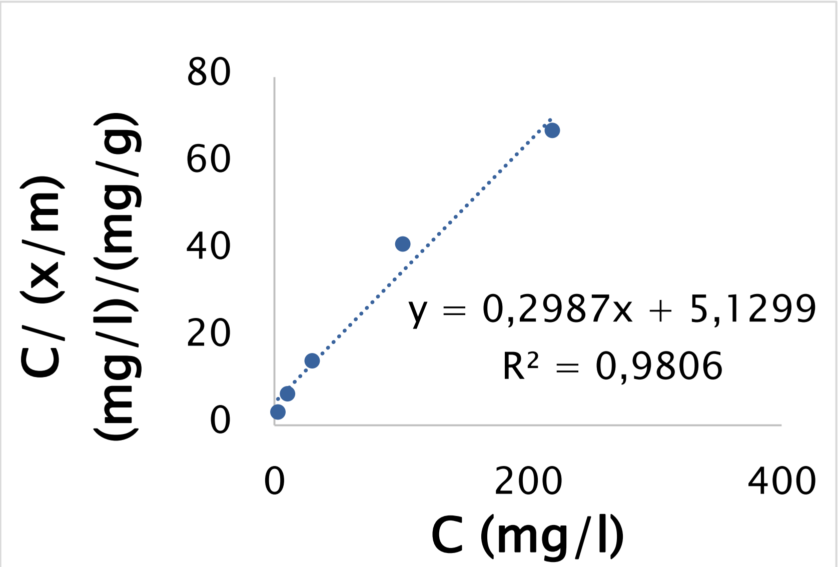
# Sorption capacity determination



- **Test n° 1: costant solid liquid ratio, different Cd concentration**
  1 g of biochar, 100 ml of cadmium solution, Cd concentration 1.25-500 ppm

**Langumir equation** $$\frac{x}{m} = \frac{b \cdot K \cdot C}{1 + KC}$$




**b= 3.4 mg/g**

**b**= Maximum amount of sorbate which can be retained by the sorbent

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# Sorption capacity determination

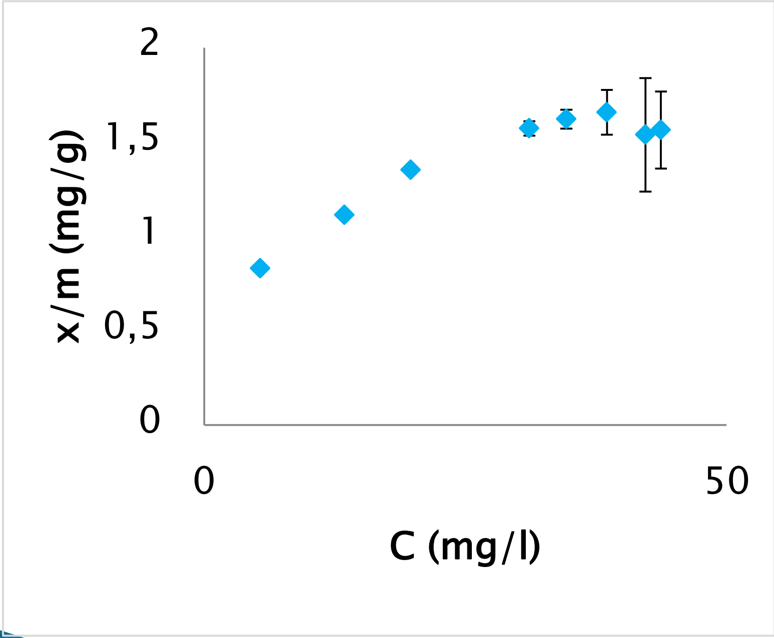


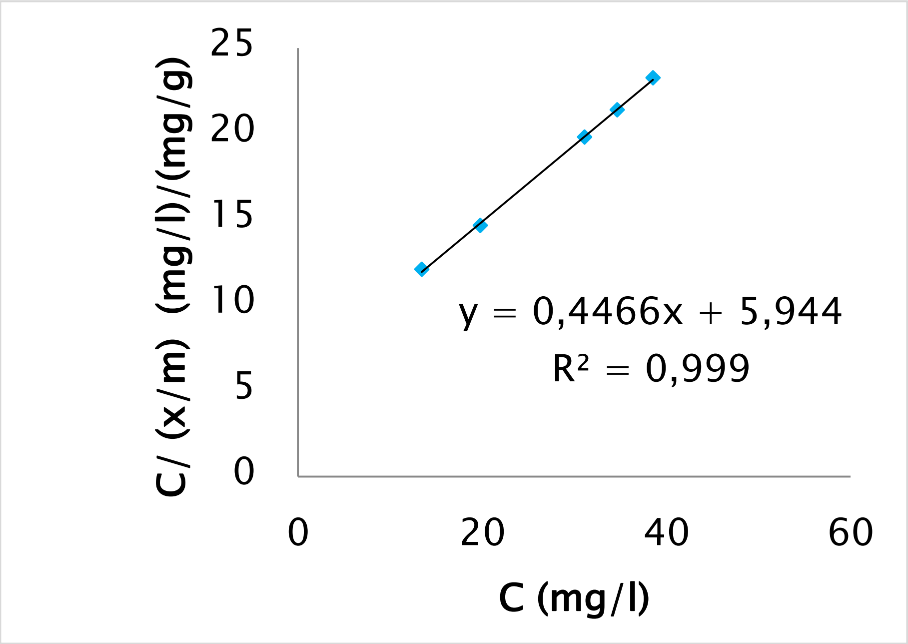
- **Test n° 2: constant Cd concentration (50ppm), different solid liquid ratio**

Volume 100 ml

**Sorbent amount 0.2-5 g**

**b = 2.2 mg/g**



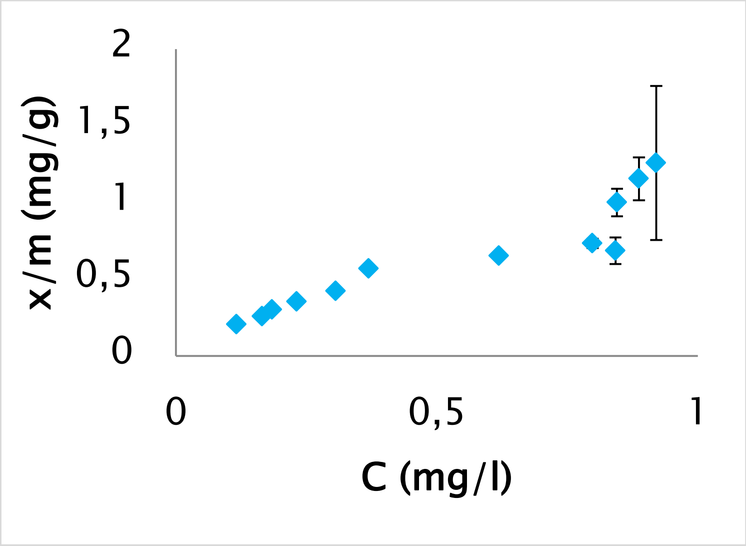

ASTM D3860 – 98

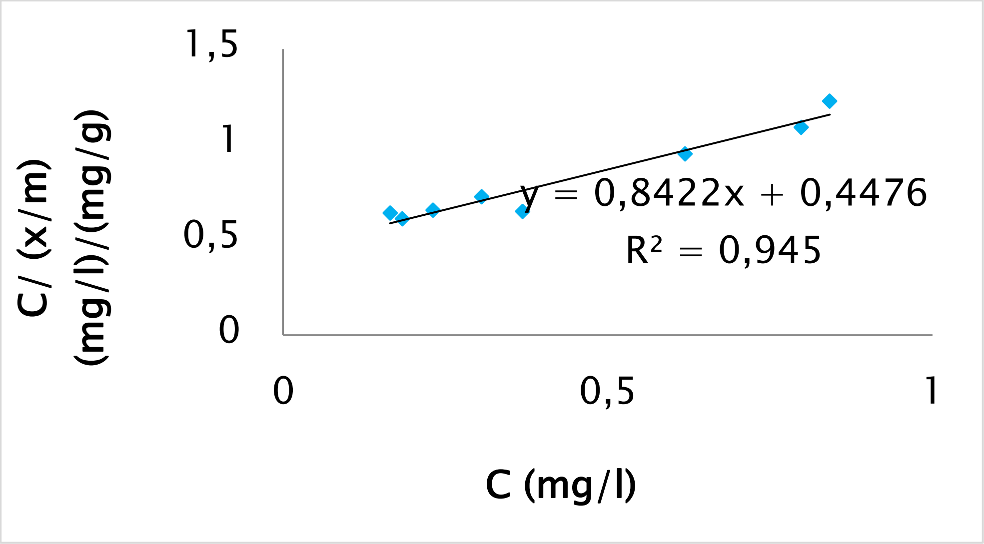
# Sorption capacity determination



- **Test n° 3: constant Cd concentration (1 ppm), different solid liquid ratio**
  Volume 500 ml **Sorbent amount 0.01 –2 g**

**b = 1.2 mg/g**






ASTM D3860 – 98

# Conclusion

- **Biochar chemical characterization is useful to give safety information:** biochar compliance has been verified and confirmed

- TGA can give useful information about the **biomass conversion.** Even if the gasification system works at 700-800 C°, it produces a biochar that has an high concentration of volatile matter (30%). **Biomass conversion can be improved.**

- **Sorption Isotherm Curve** could be useful for a relative comparison of biochar adsorption capacity.

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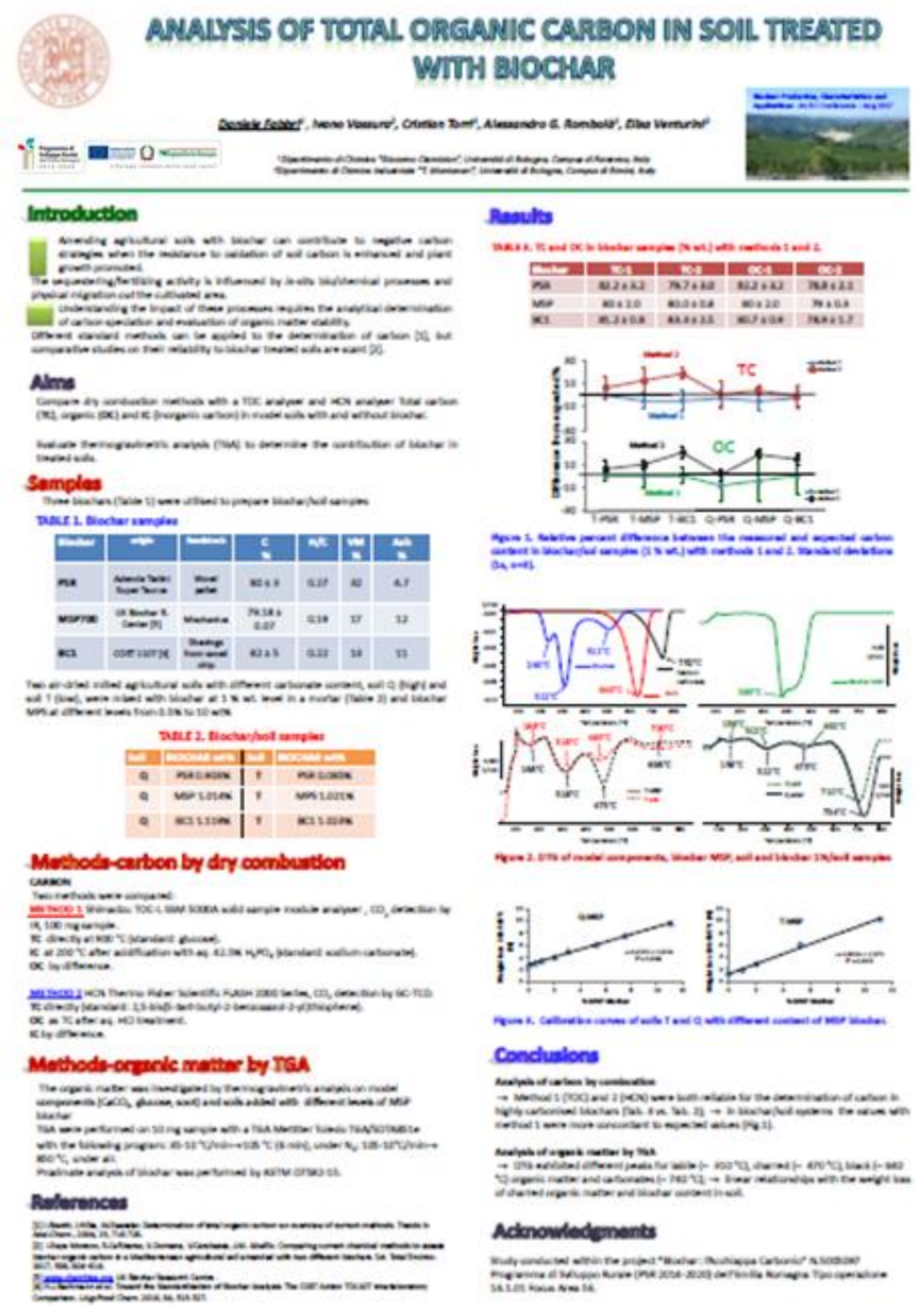
Understanding the impact of soil amendment requires the **analytical determination of carbon speciation** and evaluation of organic matter stability.

## Some conclusion…

TOC and HCN Analyzers were both reliable for the determination of carbon in highly carbonized biochars. In biochar/soil systems the values obtained with TOC analyzer were more concordant to the expected values

Potentially, TGA technique could be applied for the quantitative analysis of charred carbon in soils.

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# Thank you !