Biochar

Product to mitigate climate change and strengthen regenerative agriculture in biofuel production

Biochar is a solid product with a high concentration of carbon, highly stable and resistant to biological decomposition. It is obtained from biomass pyrolysis, a thermochemical process characterized by heating the raw material to high temperatures in the absence of oxygen. This process breaks down molecules from the biomass and rearranges the chemical bonds to form biochar, as well as other compounds concentrated in carbon, for example bio-oils and syngases that can be reused for energy purposes.

Biochar differs from charcoal mainly due to its application as an agricultural soil improver capable of increasing productivity and reducing greenhouse gas (GHG) emissions from biomass that would otherwise decompose quickly (IPCC 2022).

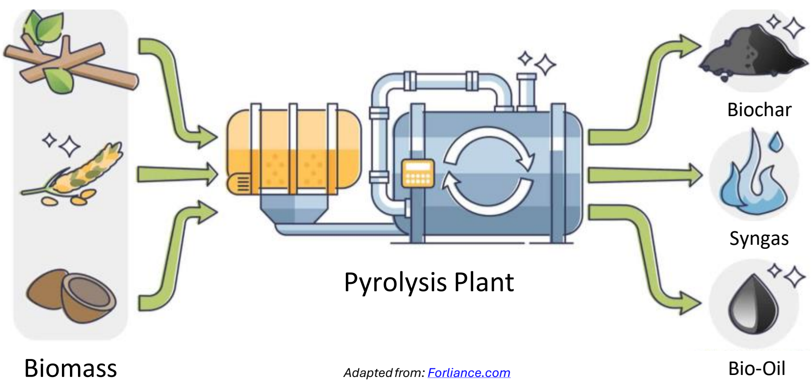
Types of biomass/raw material

Agricultural residues and biosolids in general, such as: bark, leaves, straw, bagasse, bunches, chips, manure, husks, among others.

Main examples for Brazil:

- Straw (sugarcane, corn, cereals)
- Husk (coffee, soybeans, coconuts, peanuts)
- Curls (palm, macaúba, açaí)
- Forest residues
- Other lignocellulosic residues

Biochar production flowchart



Solid phase

High carbon content and degree of aromaticity. High stability and resistance to decomposition.

Gas phase

Composition of gases with energy value, due to the presence of H2, CH4 and CO.

Liquid phase

A mixture that contains various organic compounds and water. Also known as tar.

The pyrolysis products (biochar, syngas and bio-oil) are extremely heterogeneous, with complex structures and varied chemical composition, which make them hard to standardize. The main reason is that they are produced from a wide range of biomass with dissimilar physicochemical characteristics.

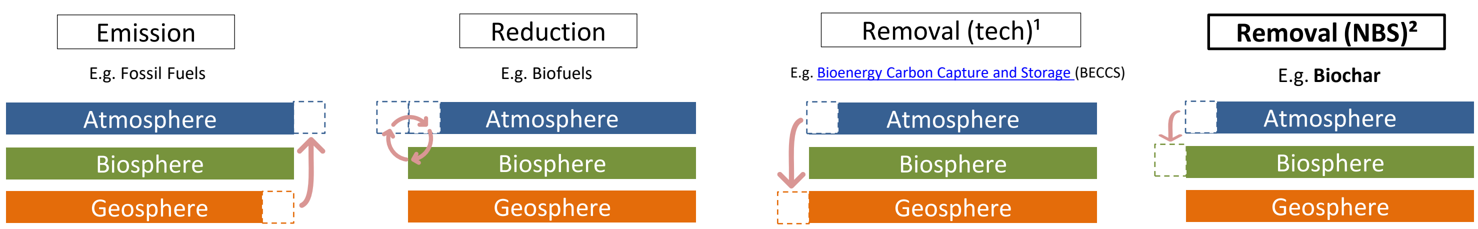
Biochar, a recognized carbon removal solution

The global carbon flow can be characterized, in a simple way, in 3 main activities: emission, which would be the release of carbon into the atmosphere, mainly through human activities such as the burning of fossil fuels; reduction, which involves decreasing carbon emissions into the atmosphere through more sustainable practices, such as the use of renewable energy; and removal, which consists of removing carbon from the atmosphere.

The international scientific community, represented by the IPCC (Intergovernmental Panel on Climate Change), has already found that climate change mitigation measures focused only on **reducing GHG emissions will not be enough to contain global warming** to safe levels for society (increase of up to 1.5°C in the global average temperature), thus implying the need to **adopt carbon removal practices** capable of **effectively removing carbon from the atmosphere**.

Biochar, in addition to being a scientifically recognized carbon removal option, is also a nature-based solution (NBS) that can provide several environmental benefits beyond the carbon sequestration.

Representação dos fluxos de carbono entre atmosfera, biosfera e geosfera



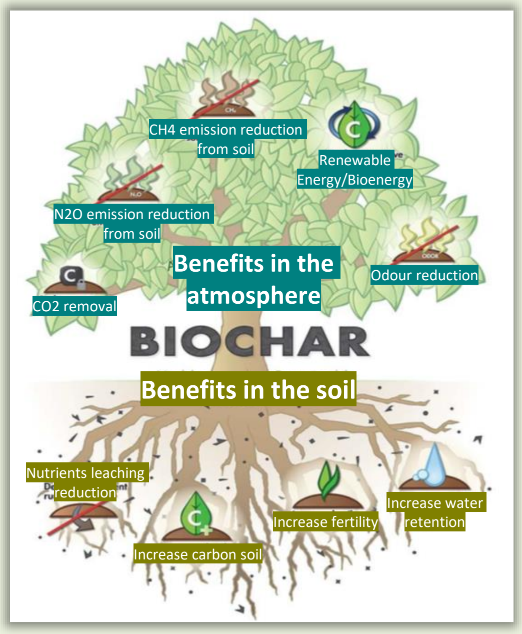
Source: EPE, based on Smith et al. (2015) and The Economist (2019).

¹ ² According to the understanding of the European Parliament, carbon removal technologies can be divided into 2 categories: technological solutions (ex: BECCS and DAC – Direct Air Capture) and nature-based solutions (ex: Biochar). Other examples of nature-based solutions would be reforestation and wetland restoration, for example.

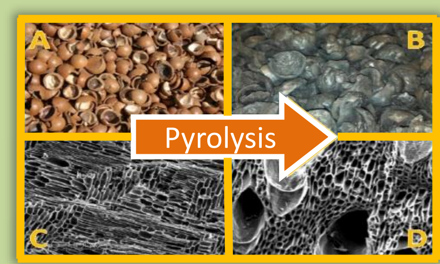
Biochar in agriculture and climate change mitigation

When applied in agriculture, biochar react as a carbon sponge that retains water and nutrients, being a soil conditioner capable of generating productivity gains and reducing fertilizer use.

In a climate perspective, in addition to permanently removing carbon from the atmosphere, biochar can also reduce emissions from other soil´s GHGs, such as nitrous oxide [N2O] and methane [CH4] from fertilizers and the decomposition of soil organic matter. Since emissions from the agro-industrial sector are difficult to reduce and represent more than 30% of global emissions (FAO 2022), biochar is a promising alternative for mitigating climate change.



Adapted from: medium.com/o-que-é-biochar



Adapted from https://stormwater.pca.state.mn.us

A: Biomass collected and treated to enter the pyrolysis reactor

B: Carbonized biomass from intermediate stage of pyrolysis

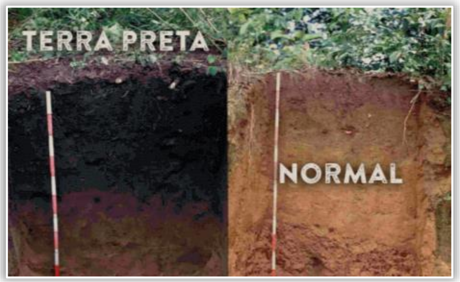
C: Microscopic image of carbonized biomass, with the onset of pore formation

D: Microscopic image of the physical structure of biochar (completely carbonized biomass), with well-developed pore system

The "sponge" effect of biochar comes from its high porosity and diversity of chemical-functional groups, thus enriching the physicochemical properties of the soil. Pores have the ability to boost the habitation of microorganisms that make up the soil biota and to increase the contact surface between different elements in the soil, thus resulting in the various benefits described above and in the figure on the side.

It's worth noting that these benefits are expected results, not guaranteed. For each project – depending on the type of raw material, type of soil, among others – these benefits can arise in different magnitudes and proportions. Hence, it is recommended to consult a specialist to better estimate the potential agronomic gains. In addition, biochar's potential to remove carbon from the atmosphere is directly related to its period of permanence in the soil; therefore, any intervention, intentional or not, that causes the removal of biochar applied to the soil can eliminate such gains.

HISTORY of BIOCHAR



Source: 'More-than-sustainable' cultural forests of Amazonian pasts - :subsistence matters:, extracted from: openendedsocialstudies.org

Indigenous Black Earth – "*Terra preta de Índio*"

The use of biochar in the soil dates back thousands of years, with archaeological evidence pointing to its use in the Brazilian Amazon.

The dark horizons in the superficial layers of the soil that make up *Terra Preta* were probably originated by human (indigenous) action, through the accumulation of organic waste and the use of fire in its carbonization, which resembles biochar. Its application in the soil led to a significant increase in fertility and amount of accumulated organic matter, contrasting with the adjacent non-anthropized soils of the Amazon basin.

Overview of the biochar industry

While carbon removal technologies are in the development phase (e.g. BECCS, DAC), biochar accounts for about 95% of the credits in removals category.

- **Biochar in Brazil:**

Industrial Plants:
(in operation): Lajinha (MG)
(under construction): Brejetuba (ES) and Machado (MG)

**The 3 plants together have the potential to produce about 12 thousand tonsBiochar/year*
**Responsible company: NetZero, in partnership with local agricultural cooperatives*

Raw material: agricultural residues (mainly coffee husks)

-> Brazil has the potential to become a leader in the production of biochar from agricultural waste, due to its high availability.

- **Biochar globally:**

Biochar companies: 230
Projects in operation: 93
Main raw material: wood chip
Continent with the most projects: Europe
Volume CO2 removed/year: 770 thousand tonCO2

Largest 5 plants (55% of total capacity):

Pacific Biochar/Pacific Biofuel Holdings
Exomad Green
Carbon C2
Dutch Carboneers
Avenger Energy

2030 scenario: estimated ~2M tonCO2/year removed with announced biochar projects.

Source: Allied-Offsets (CDR report april 24)

Certification and Carbon Credits

Today, it is already possible to generate carbon credits through projects from the production and use of biochar in agriculture, thus creating a second source of income for feedstock producer.

In general, in order to generate carbon credits with biochar, it is necessary to guarantee:

(a) Sustainable sourcing of raw materials
(b) Controlled production [pyrolysis] with reuse of syngases
(c) Permanent carbon removal (e.g. land application - agriculture)

The generation of carbon credits involves several steps, such as: Project development, registration, measurement, monitoring, reporting and verification.

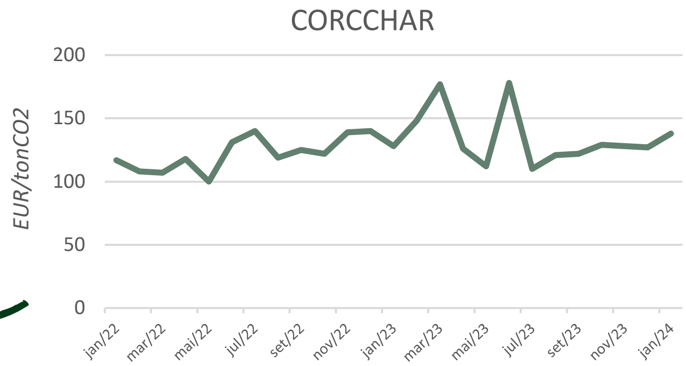
- Key global standards with methodology developed for certification of carbon removal projects with biochar:

Click in the images:

Through a partnership between Puro.Earth and Nasdaq (American stock exchange), a price index was created for carbon removal certificates via biochar, called "CORCCHAR". The chart on the right shows the price history of the "CORCCHAR" index, which oscillates in the range of approximately 100 to 180 EUR/ton of CO2 removed.

- Main digital platforms for trading biochar carbon credits:

Click in the images:



Adapted from: Puro.earth Carbon Removal Platform | Nasdaq

It is possible to identify that, due to the ability of biochar to permanently remove carbon from the atmosphere and generate several other environmental benefits (as mentioned before), the price of carbon removal credits from the production and use of biochar are relatively higher than the other categories. It is worth noting that the amount of credit tends to vary according to the individual characteristics of each project.

It is estimated that the cost of production and use of biochar ranges between EUR 80-110/tCO2 removed (EPRS 2021). Adopting this investment range as a premise, the value of the biochar carbon credit recently observed in the market (ranging from 100 to 180 EUR/tCO2) could provide financial feasibility of a biochar project, in addition to possible additional gains in agricultural productivity and reduction of GHG emissions*.

Carbon credit price per category

	~EUR/tCO2
Biochar	***100 - 180***
Agriculture	16
Forestry	5,5
Residues	4
Energy Efficiency	3,5
Chemicals	3
Transport	3
Renewable Energy	2,5

Adapted from: AlliedOffstes e Eco-Engineers – carbon markets snapshot

**The financial feasibility of a project should be analysed on a case-by-case basis, according to its local characteristics and considering all direct and indirect costs.*

Biofuel Carbon Intensity

Life Cycle Assessment (LCA), an environmental impact measurement tool widely used by renewable energy programs of the transport sector, allows estimating the carbon intensity (CI) of biofuels that use biochar in the agricultural phase of their production process.

Using sugarcane ethanol as an example, the use of biochar in soil during cultivation has the potential to reduce around 2 gCO2/MJ of ethanol per year, for each ton of biochar applied per hectare*. This potential refers only to the CO2 removed in biochar, without accounting for possible additional productivity gains and reduction of N2O and CH4 emissions from the soil.

**Simulation based on average values from the literature. 2 tonCO2/tonBiochar; 80 tons/hectare; 85 litersEthanol/tonSugarcane; sugarcane cycle of 6 years; 21.3 MJ/LiterEthanol.*

The European Renewable Energy Directive (EU-RED), for example, already recognizes biochar as a CO2 removal option. The program regulation extends the CI reduction limit up to 20 gCO2/MJ additional to biofuels that use biochar in their production process (EU 2022/996).

Novel decarbonization programs that considers EU-RED as a benchmark regulation, such as the aviation sector's CORSIA, may represent an opportunity for biofuel producers to increase their competitiveness with the use of biochar. The National Biofuels Policy (Renovabio) does not yet recognize carbon removal actions as a tool to reduce the CI of biofuels, but the program's continuous improvement agenda may incorporate such actions in the future.

epe
Empresa de Pesquisa Energética

Director
Heloisa Borges Bastos Esteves

Technical coordination
Angela Oliveira da Costa

Technical staff
Arthur Cortez Pires de Campos
Danilo Perecin
Rachel Martins Henriques
Rafael Barros Araujo

To learn more:

International Biochar Iniciative
Biochar for Sustainable Soils
GBEP - Website: Biochar webinar series

Publicado em: 12/08/2024