INDUSTRIAL LEVEL combustion chamber for household heating and biochar production. Photo: nordregio.org

Biochar: the „real“ black gold

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You might have heard about it, or at least it might sound familiar, but what is biochar? First of all, biochar is not charcoal. While the more commonly known charcoal is burned as fuel for heating and cooking, biochar is primarily a soil amendment. Both emerge as a result of heating woody or organic matter, a process which is commonly termed pyrolysis, and both have been traditionally created in very simple ways in most parts of the world. But while charcoal is typically just an analogous material to coal, there is much more to biochar.

What is it useful for?

Unlike charcoal, biochar can have a decisive role in averting soil degradation and climate change. Biochar has a number of very interesting characteristics which

THE PRODUCT of complete pyrolysis which can no longer be used as fuel but serves as a soil amendment and helps to sequester carbon from the atmosphere. Photo: PIN

makes it useful for a range of purposes. When observed under an electronic microscope, biochar particles contain myriads of small geometric caverns and “cells.” Due to an extremely high surface area, and the ability to chemically bind all sorts of chemicals, biochar serves as and excellent adsorbent of not only nutrients for plants, but also toxic substances and pathogenic bacteria. The ability to bind nutrients significantly reduces the demands of biochar amended soils for fertilizers, both chemical and organic.

Bacteria like biochar a lot: its high surface area and ability to bind soluble nutrients serve as a breeding ground for soil bacteria, but also as a “shelter” for them in times of drought. Note that soil bacteria are vital for soil fertility, have the ability to support “higher level” biodiversity, such as earthworms, and are responsible for creating the “structure” of soil as they construct and maintain a net of soil micropores, which allow for the passage of oxygen, water and help prevent soil compaction. Due to its high absorbance, biochar is also used in various filters to separate toxic substances from air and water and can also easily be used in solid waste treatment (i.e. in toilets) as an additive to boost its natural decomposition

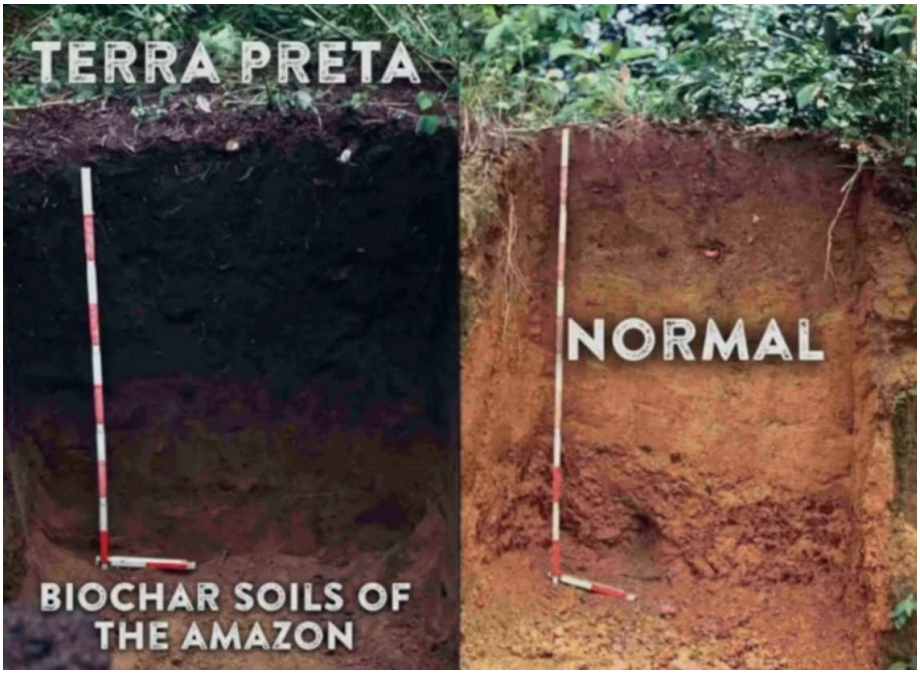
and composting. Biochar is also typically used as "carbo medicinalis" during stomach-aches as it helps ease stomach and digestive tract infections thanks to its ability to adsorb bacteria. This can also be used to improve the health of livestock and poultry, if used as an additive in their feed.

For the purpose of soil amendment, biochar can by distinguished between "activated" and "non-activated" biochar, where "activated" means that bacteria had already colonised the material (which changes its physical, biological, and chemical properties). In any agriculture usage, biochar used should always be "activated" before its application, either by mixing in compost or human/animal liquid or solid waste and left for a number of days to colonise itself. Note that other means of activation are possible, but typically the two mentioned above are most feasible.

Another advantage of biochar is that is serves as a strong adsorbent of water. This makes biochar very suitable for increasing the resilience of soils to droughts. Biochar particles serve as sponges which inflate as they come into contact with water. Thus, biochar becomes extremely relevant in drought-prone and generally arid areas as it both reduces the demand of plants for watering and prevents the general runoff of water from soils making them less prone to drought related degradation and erosion. Increased water retention represents a key adaptation strategy to help cope with the adverse effects of climate induced droughts and/or the increased frequency and severity of rains and storms normally resulting in soil erosion and a loss of soil fertility. It also helps reduce the costs for watering, water delivery and extraction and generally helps to reduce the uptake of surface and subsurface water preventing droughts.

Third, and no less relevant, is the potential of biochar to resist its own degradation and thus to have the capacity to last in soils for hundreds and thousands of years. As biochar is almost completely composed of pure carbon, its inclusion in soils helps sequester carbon from the atmosphere and could, in theory, be used to mitigate a significant portion of human-induced global warming. When burning, around 50% of the carbon content of the fuel's biomass is converted into biochar and can be stored in soils. Biochar has therefore, both very strong adaptive as well as mitigative potential when it comes to addressing climate change, can be used to treat pollution, both chemical and biological, has medical benefits, and can significantly reduce the costs of plant production, while increasing the fertility of soils and thus production of crops. Can you imagine anything as valuable, yet easy to make, as biochar? That's why it is referred to as "black gold."

"...biochar can have a decisive role in averting soil degradation and climate change."



THE BLACK SOIL, also called "terra preta" can be found in many places in the Amazon rainforest and serves as proof that biochar has been burned and used by ancient inhabitants of the forest to increase the fertility of the traditional agroforestry system. It is a simple technology indeed, yet largely unknown and unutilized in the developed world today. Photo: www.vitantica.net

How is it made?

Typically, woody or plant-based matter is burned in stoves or open fires in order to produce heat, cook food or heat houses. Thus the material will burn down completely (under fully oxygenic conditions) resulting in white ash. This process can release a mixture of irritating particles and gasses, depending on the technology used for the burning. During pyrolysis however, organic material is heated to release combustible gases, which then burn as they come into contact with oxygen in the combustion chamber. It sounds complicated, but in fact this can be done in a truly primitive way, either in a cone-shaped earth pits (fireplaces with conic shaped holes) or similarly shaped metal (or other materials, such as clay, would work as well) containers.

Why is it interesting for the economically vulnerable communities?

Besides simple pits and the so-called "retorts," biochar is typically burned in modified stoves, also referred to as rocket stoves. These increase the efficiency of biochar creation and allow the utilization of the heat, which is produced as the combustible gases burn. But unlike typical burning, pyrolysis releases minimal pollution and is thus much less hazardous to health and more suitable

MAKING OF BIOCHAR left: in a conic shaped pit and right: in a metal mobile retort Photo: PIN

for usage indoors. Since woody types of fuel (wood or charcoal) are still very much used throughout the countries of the global south, a large proportion of the population is exposed to irritating smoke causing respiratory issues. This also means that a very large proportion of the poorest population is using wood, plant- or wood-based fuels which could be turned into biochar and become a key ingredient in increasing the resilience of the most vulnerable communities.

To sum up, biochar can be beneficial especially to the poorest communities exposed to multiple threats including water scarcity, soil degradation, climate change, water and human waste treatment, health of people and animals including respiratory diseases prevention, fuel scarcity and energy poverty.

Rocket stove

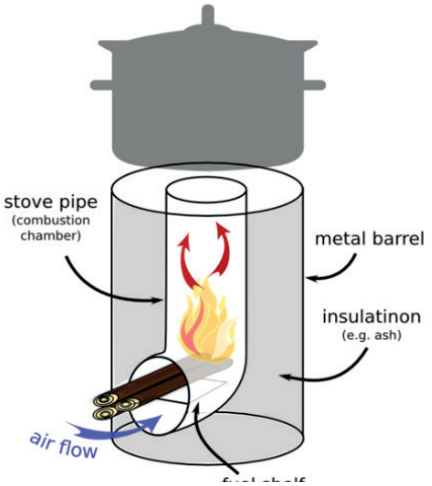
A rocket stove is a super-efficient small combustion stove. Its intelligent design makes use of any small fuel sources such as twigs, small branches, pinecones, and dry grass. This means a fuel source is: More readily available, easy to gather, transport and can be sustainably cultivated! But most of all, it is FREE (no need to mine, process and transport it like e.g., LPG, solar panels, charcoal, eco-briquettes).

These small fuel sources are burned in a combustion chamber containing a vertical chimney. The design ensures nearly complete combustion. This means you're getting more heat output (for warmth or cooking) than traditional firepits or even wood stoves.

The first ones built were based on an old lamp design that has been around since at least the 1700s. Since those early years, it's undergone incremental improvements over the centuries. The modern-day rocket stove was officially designed in the 1980s. They were originally built to support an improved cooking system for impoverished communities. It is worth noting that the modern design did not gain a significant popularity among the target audience, but there are also traditional and adapted traditional stove designs which are designed on the same principle and could be more successful at overcoming cultural barriers.

The simple design of the rocket stove captured the world, because they are relatively easy and inexpensive to build. Even with scrap materials from a recycling bin or a small amount of concrete! Unlike a traditional wood

LEFT: popular three-stone technique of household cooking, often performed in black kitchens with poor ventilation and RIGHT: improved rocket stove design with a biochar chamber, saving fuel and effectively cooking without the creation of irritating smoke. Photo: PIN



BASIC ROCKET STOVE DESIGN. Note that in household environments where the purpose of the stove is to heat the house while cooking, the combustion chamber's insulation is unnecessary.[1] Photo: Wikipedia

stove, a rocket stove has no moving parts. This means no flue damper and no air inlet grate!

The basic rocket stove has only 4 components:

→ The "Elbow" – a fire-proof L-shaped pipe with a 90-degree bend in the middle. The horizontal portion of the elbow is the fuel chamber and air inlet. The vertical portion is the combustion chamber and chimney.

→ The Stove Body – an insulated surround for the elbow, capable of withstanding the high heat from the elbow. Large metal food cans (or metal trash cans) work great, as does sheet metal bent to fit around the elbow. A hole in the top allows the chimney to exit upwards. And a hole on one side allows access to the fuel chamber and an air inlet.

→ A Fuel Grate – ideally the fuel needs to sit up off the bottom of the fuel chamber. Normally a metal shelf provides airflow under and around the fuel. This allows any ash to fall through and be removed.

→ A Pot Skirt (optional) – this allows you to place a cooking pot on top of the chimney. It maintains an air gap to allow hot-rising gases to escape the elbow. The pot skirt also blocks the wind from the bottom of the pot. This helps provide for better heat transfer for faster cooking.

Distribution of population according to the primary* fuel used for cooking (2011)

COUNTRY	% MODERN FUELS** OR COAL	CHARCOAL OR COAL			% OTHERS (crop, residues, etc.)
		together	% charcoal	% wood	
Benin	6,2	92,8	22,9	70,0	1,1
Burkina Faso	8,1	90,5	4,9	85,6	1,4
Cape Verde	64,2	33,4	0,0	33,4	2,4
Ivory Coast	16,1	83,7	22,3	61,4	0,2
Gambia	5,5	89,6	14,3	75,3	4,9
Ghana	15,0	81,6	38,1	43,5	3,4
Guinea	23,7	74,6	74,2	0,4	1,7
Guinea Bissau	1,9	97,5	33,6	63,9	0,6
Liberia	0,2	98,8	48,1	50,7	1,0
Mali	0,5	96,0	17,4	78,6	3,5
Niger	0,9	97,0	2,9	94,1	2,1
Nigeria	32,6	65,6	2,9	62,7	1,8
Senegal	38,6	58,2	7,8	50,3	3,2
Sierra Leone	0,8	98,7	14,8	83,8	0,5
Togo	1,7	97,7	41,8	55,8	0,6
ECOWAS countries	**22,7**	**75,4**	**12,9**	**62,5**	**1,9**

* fuel used most often for cooking the main daily meals.
** gas (including LPG), kerosene and electricity.

Source: World Health Organization data base (WHO), 2009; Programme regional pour la promotion des energies domestiques et alternatives au Sahel (PREDAS) du Inter-States Committee for Drought Control (CILSS).

First, the fuel blocks most of the air inlet, providing a limited amount of air for the fire. This forces the air in a smooth stream under and around the fuel. As this current passes around the tip of the fuel, it provides a constant stream of fresh air to the fire. Second, the fire is only burning at the tip of the fuel. As you slide more fuel into the chamber, it advances the burning material into the air stream from the inlet. This makes it easier to control the burn rate and to keep an even temperature. Third, with the pot positioned above the chimney, you focus as much heat as possible onto your cooking pot. This means little waste and less fuel is needed to get dinner on the table!

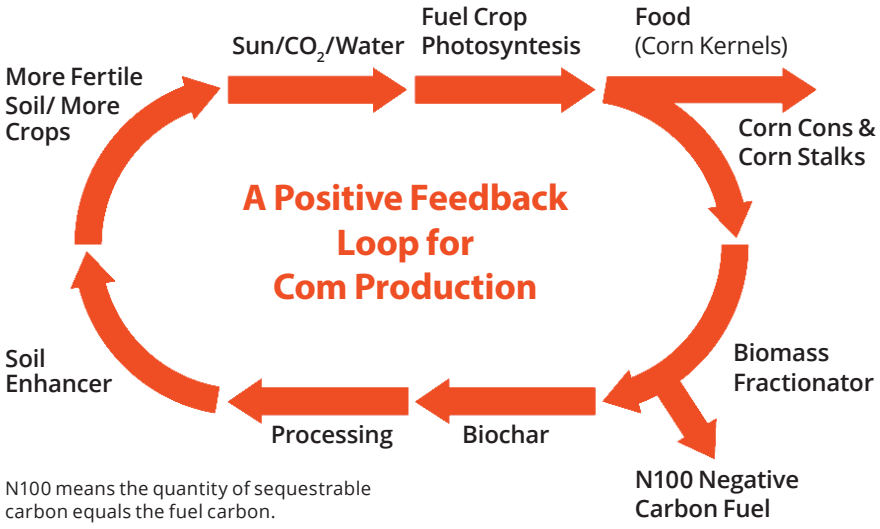
Biochar and circular models of production

Biochar manufacturing should never be the only purpose of burning organic material, but mainly as a by-product of heat and energy production. Rocket stoves used for cooking and heating not only improve fuel use, but

THE PRODUCT of complete pyrolysis which can no longer be used as fuel but serves as soil amendment and helps sequester carbon from the atmosphere. Photo: Wikimedia

also produce biochar which can have a lot of other uses in a household; but one of the most interesting ways of using it would be to enrich the soil and thus support the production of woody biomass, i.e. fuel. That way, biochar can be the element closing the loop between fuel production and combustion. Sustainable energy models using biochar can only be of benefit if they do not lead to deforestation or the removal of naturally occurring vegetation. The key idea is that biochar is used to improve soils where fast-growing woody plants used as fuel are sustainably cultivated (e.g., bamboo, willow, poplar, eucalyptus) or harvested. These then serve as a source of energy and biochar, leading to further soil improvement and higher wood yields.

Biochar can also be used in toilets, household vegetable gardens and smallholder fields, where plant-residues can also be burned in a similar manner and supplement the primary fuel crop (fast growing trees or bamboo). This model is feasible in any rural or urban community both in poor and ultra-rich contexts. It typically includes a strong community element, where inhabitants can be included in biomass collection, cultivation and biochar utilization including using it for heat in households. In urban areas, biochar can significantly contribute to the survival and functioning of urban vegetation, reducing the costs of watering and thus, contribute to the reduction of the urban heat island effect while producing woody materials for making biochar and heating houses.



A CIRCULAR MODEL of food and fuel production based on corn cultivation and corn biomass combustion with biochar by-product.

Use cases:

Stockholm Biochar Project: Managing the increasing amount of waste generated in urban spaces is a common challenge to cities worldwide. Since March 2017, Stockholm has been working to address this problem by opening the first large scale biochar plant. This project reduces carbon emissions while engaging people in the fight against climate change. Residents provide garden waste to the city, which produces biochar – a charcoal-like product that sequester carbon in soil for thousands of years.

There are also a number of examples of applied and research projects in global south countries. If you are interested to know more about them, it is worth exploring at the link below.

https://biochar-international.org/biochar-in-developing-countries/.

1 https://3.bp.blogspot.com/-5LuhdNbngMs/USWYI3f2PxI/AAAAAAAAASs/OGaWctWaAtM/s1600/Rocket_stove.png