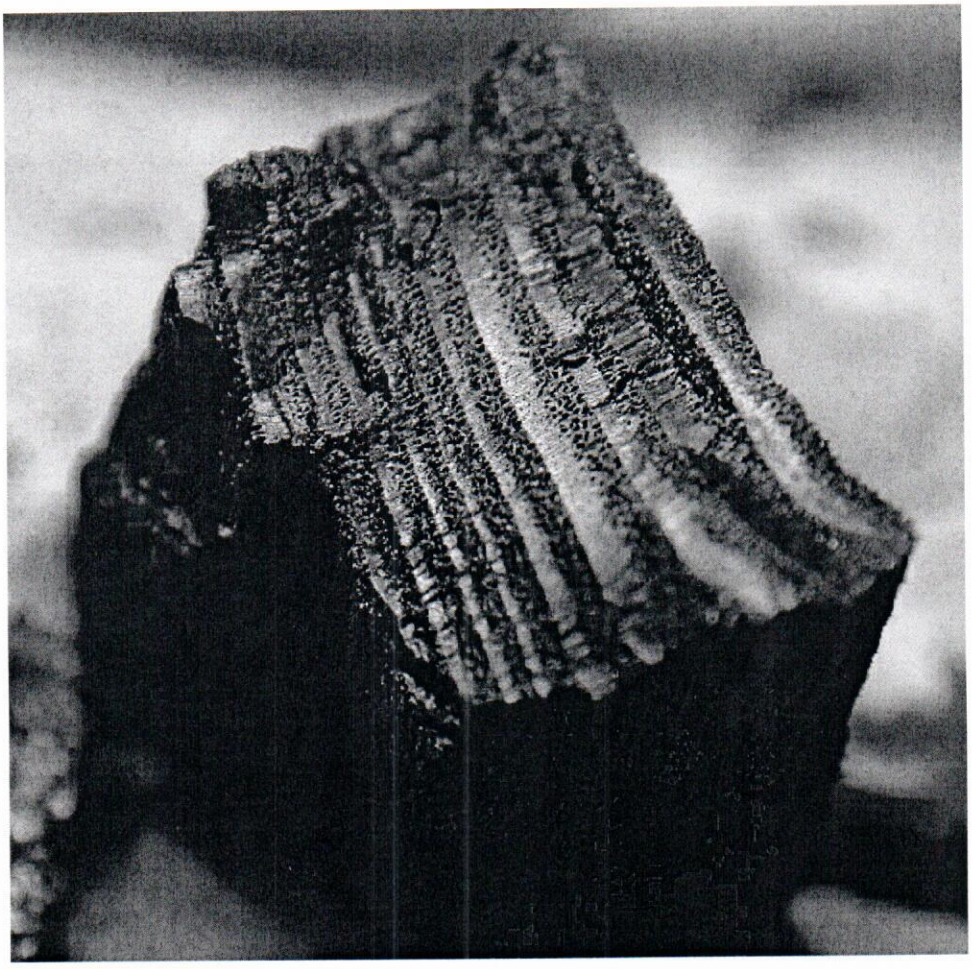
Ways of Making Terra Preta: Biochar Activation

by Hans-Peter Schmidt

Biochar is not a fertilizer, but rather a nutrient carrier and a habitat for microorganisms. First of all, biochar needs to be charged to become biologically active in order to efficiently utilize its soil-enhancing properties. There are numerous methods of activating and producing substrates similar to terra preta aside from mixing biochar with compost.

Biochar is extremely porous and has a huge surface area of 300 m2 per gram. Due to its high porosity, biochar can incorporate up to five times its own weight in water and dissolved nutrients. This property is called adsorption capacity (AC) and depends on the pyrolyzed biomass and the pyrolysis temperature. The highest adsorption capacity of biochar is achieved within the temperature range of 450 ° C to 700 ° C.



Porosity of a coal ash clearly visible to the naked eye. (Photo: Andreas Thomsen)

Another important feature regarding the particular nutrient dynamics of biochar is its high cation exchange capacity (CEC). The CEC is a measure of the ability to bind positively charged ions (cations) on biochar's surface and make them available later, under appropriate conditions, to plants and microorganisms. While CEC depends on the surface of biochar, it is also a chemical value, which increases through oxygen and contact with the soil and reaches its

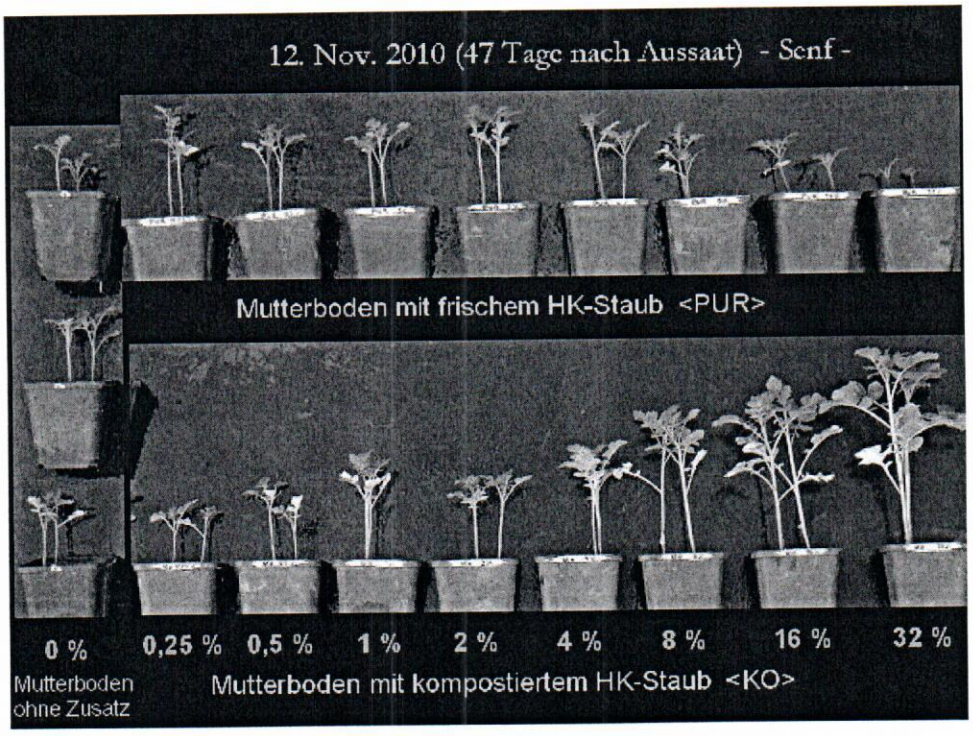
maximum value only after some time. A high CEC prevents the leaching of mineral nutrients, such as organic nutrients, and assures high nutrient availability. Further, a high CEC also binds toxic molecules, thereby protecting the soil.

The combination of biochar's high AC and CEC make it a perfect nutrient carrier. Microorganisms find ideal habitats in and around the biochar through these absorbed nutrients, which, in turn, benefits the entire soil microbial life and promotes the potential for symbiotic microorganisms and plant roots.

Principles of biochar charging

If biochar is incorporated pure and without activation into the soil, its high adsorption capacity and increasing CEC will result in the absorption and fixing of available nutrients and water in the soil. This may lead to inhibition of plant growth, at least in the beginning (several months to a year), depending on the soil's nutrient content. To prevent this, it is recommended that prior to biochar's application, biochar should be:

1. Loaded with nutrients and water
2. Colonized with microorganisms to ensure the fixed nutrients are more easily available to plants
3. Aged by oxidation to bring CEC close to its maximum.



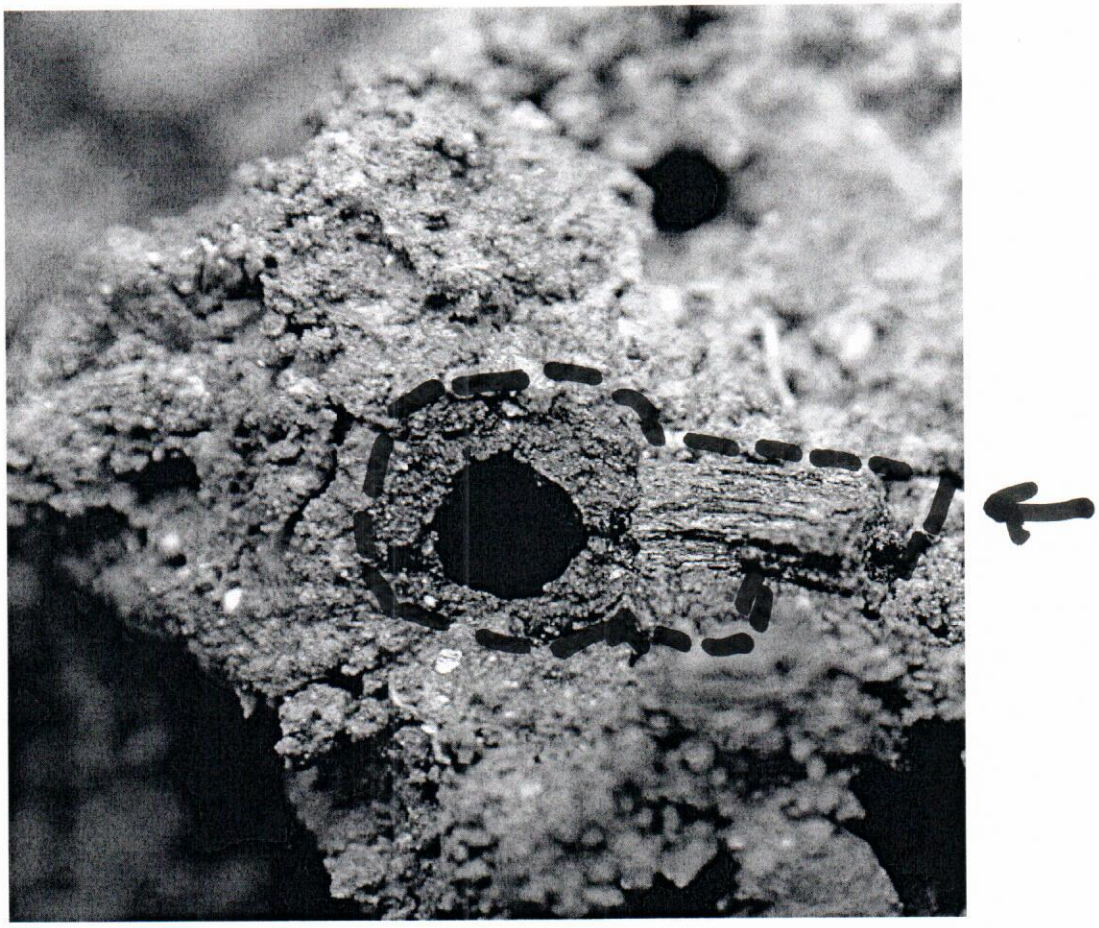
The experiment by Andreas Thomsen clearly shows the importance of charging biochar. In the picture, the upper portion shows a series of experiments wherein pure biochar particles were added in increasing dosage. In the lower series of the picture, the biochar was composted first for 4 months and then cleaned of compost to make sure that only the charged biochar in the experiment was used. While pure biochar resulted in growth inhibition of mustard plants, charged biochar showed a significant increase in growth (thanks to Andreas Thomsen).

There are many different viable processes in charging biochar and, thus, producing terra preta soil-like substrates. These variables are adjusted and modified depending on location, culture, climate, and existing techniques. Many of

these procedures have evolved over time or in accordance with good agricultural practice. While there is no universal formula (although patents have already been registered), the following basic principles hold:

1. Enough moisture present so that nutrients can dissolve and the pores of the coal can charge
2. A high diversity of organic nutrients in order to prevent shortage of certain nutrients
3. The most important nutrients for microbial colonization are organic carbon and nitrogen, which are particularly limiting in fresh coal
4. The C / N ratio of the biochar-substrate should be 25 to 35
5. The duration of the charge should be at least 14 days
6. Inoculation with soil-borne microbes through the addition of humus-rich soil, compost tea, compost, or by selected microorganisms

The following four systems and procedures are examples of the practical implementation of biochar activation for agriculturally related quantities. These procedures can also be adapted for a small garden or even a balcony:

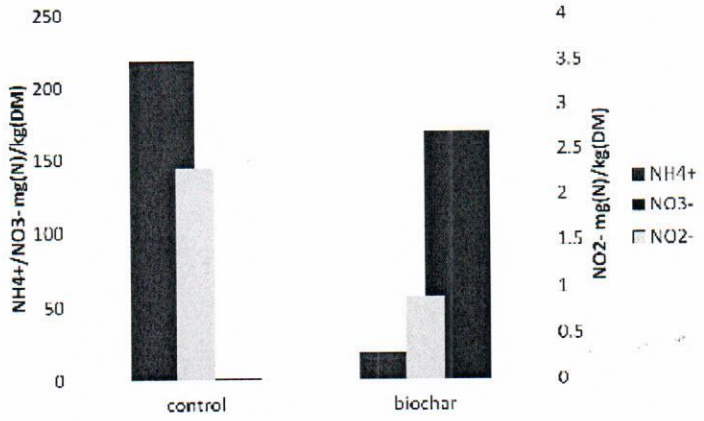


Soil from a vegetable patch with biochar compost (about 25 cm deep). An earthworm has lined its path with biochar-containing solution. By the way, many laboratory tests have shown earthworms to be a great lover of biochar substrates. Diameter about 4 mm. (Photo: Andreas Thomsen)

A. Biochar with compost

The charging of biochar by addition and mixing of compost probably represents the best way to produce terra preta and similar substrates. Microbial stimulation is highest in compost: nutrients are built into complex organic compounds and the final substrate is very close to the soil's humus. However, most available composts are of poor quality. Poor compost is tediously "digested" in the ground and this leads to nutrient blockage and microbial imbalance. If you are not sure about the quality of your compost, it is better resort to one of the other options for charging the biochar. Good compost must have a crumbly structure, similar to that of humus soil, and is not supposed to smell bad.

Ideally, biochar is added to the compost at about 10% of biomass when arranging the pile, to boost the compost's nutrient efficiency (see Fig.__ below). Frequent "turning" is important for oxygenation and homogenous distribution of nutrients, which, consequently, promotes microorganismal activity.



A preliminary experiment at the Delinat Institute has shown that the addition of biochar significantly improved the reaction of the nitrogen compound by stabilizing and significantly increasing plant-availability of nitrate (NO3). Nitrogen loss is slowed down and, with it, the emission of greenhouse gases. In a second, larger experiment, this effect will be verified and investigated in detail. A separate article on the topic of composting with biochar will be published in Ithaka.

The biochar produced with compost can be used again after rotting for charging other fresh biochars. Mature composts that have not been composted with biochar can also be used to activate biochar.

To activate, stack the biochar in approximately a 1:1 volume ratio with the mature compost and moisten both well. If possible, mix biochar and compost with a compost turner. This process can be repeated several times until the ratio reaches 1:1. The mixture should be prepared at least 2 weeks prior to its application into the soil and during that time should always be kept moist and turned at least twice.

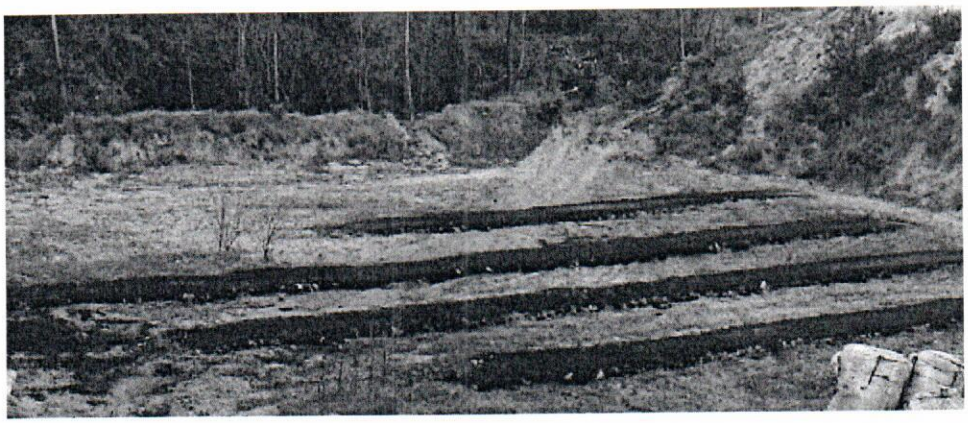
B. Biochar with manure from livestock

A mixture of different manure types is preferable to one type of manure. Attention should be given to a high straw content. Since the following method is not about composting, the manure should be stored at least 1 year prior to use. It is better, however, if the biochar is already used as bedding for the manure in the barn. Alternatively, it is also possible to regularly spread the biochar in the septic tank.

The ratio of biochar to manure should be about 4 to 1. Depending on the cultural and nutritional needs of the area, this ratio can be reduced. To prepare the biochar:

1. Moisten the biochar with plenty of water.

2. Spread out the biochar into strips/bands of about 120 cm width and a height of about 5 cm on a humus-rich soil, when possible.
3. Spread over it a 3 cm thick layer of manure.
4. Put 1% rock flour into it (not necessary, but it improves the quality of the substrate).
5. If the manure to be mixed is not high in straw content, put layers of about 10% grass, corn silage or greenwaste into it.
6. Spread over it another layer of biochar.
7. Moisten the whole with as much water as possible (if possible, put compost tea or EM-A [Effective Microorganisms]).
8. If the ground in which the mixture will be used is too firm and less productive, a layer of fresh, fertile, soil should be added for microbial colonization of the substrate to take place.
9. Roll over the band with a rotovator at least twice to thoroughly mix the substrate.
10. Keep the mixture well moisturized for 14 days and stir it every 3 days with the rotovator. It is recommended to cover it with fleece.



Activating biochar through Method 2 in the winery Pago Casa Gran, southern Spain.

C. Biochar with liquid fertilizers

1. Calculate the amount of fertilizer you need for a given area. Mixing with biochar reduces leaching and outgassing of nutrients, so that fertilizer efficiency increases significantly and a total of only half of the conventionally calculated amount is required.
2. Make sure that the fertilizer contains not only the main elements (N, P, K, and Mg) but also has a very high mineral diversity. In case of doubt, add some rock flour.
3. Dissolve the calculated amount of mineral fertilizer in sufficient water.
4. Give as much biochar in a period of 2 days to allow complete absorption of the added liquid.

Organic liquid fertilizer is preferable for charging instead of NPK fertilizer. Liquid animal manure is an excellent example to use for charging biochar.

Variant C is not about microbial colonization. In this example, colonization will take place in the soil. In organic farming, mineral fertilizer trade is prohibited.

D. Biochar – Bokashi (lactic acid fermentation of biomass)

1. Mix straw-rich manure with 10% grass clippings, 10% biochar, and 1% rock flour.

2. Spray the biomass with a solution of 3% EM-A and 3% cane molasses. (Alternatively, instead of EM-A, Sauerkraut [pickled cabbage] juice, Brottrunk [a particular juice manufactured from bread], or juices containing enzymes with similar high amount of lactic acid bacteria can be used. This can prolong the fermentation process depending on the mixture.).
3. Compress the pile by driving on it with a tractor repeatedly as shown above (see picture).
4. Cover the pile with an airtight suction foil. Cover the whole thing with a black foil and load it with gravel bags. (On a smaller scale, this can be carried out in closed containers such as buckets, barrels, or plastic bags.).
5. Remove the foil after 14 – 21 days, depending on ambient temperature. The product will smell slightly like lactic acid!
6. To activate a larger amount of biochar, the Bokashi can be filled up to 50% (vol) of biochar. For terra preta similar substrates, this additional amount of coal is not necessary.
7. Water and mix the pile with a compost turner or rotovator and let it aerate for several days. To inoculate it with soil-borne micro-organisms, add some fresh soil.

Compressing a biochar-manure mixture before covering it with an air-tight foil. Bokashi fermentation is an anaerobic process. (Photo: Rolf Zimmermann)

Incubation in the soil

The activated biochar and terra preta similar substrates should be incorporated superficially in the soil. If the appropriate technology is not available, the substrate may simply be spread on the ground. The anxious mixing by worms in the soil takes a little longer.

Tags: Aktivierung von Pflanzenkohle, Bokashi, Kompost, Pflanzenkohle, Terra Preta

Related Posts

- Kaskadennutzung von Pflanzenkohle in der Tierhaltung (Teil 1: Einstreu)
- 55 Anwendungen von Pflanzenkohle55 Uses of Biochar
- Pflanzenkohle in Kleingärten – Resultate 2011Biochar Gardening – results 2011
- Pflanzenkohle im Europäischen Weinbau: Ergebnisse 2011Biochar in European Viticulture: Results of the Season 2011