Biochar

carbon-negative **fertility, food & fuel**

Frequently Asked Questions

1. What is *biochar*?

Biochar is a new word to describe fine-grained, highly porous charcoal made from biological material (biomass), high in organic carbon. This excludes fossil fuel products, geological carbon and industrial synthetics (plastics).

A primary purpose for ***biochar*** is as soil enhancement to help retain nutrients and water, and habitat for the soil food web. This includes food-producing farm soils, so careful specifications are needed to define materials suitable for this use.

2. Why should I be interested in *biochar*?

Biochar is a key element in a new carbon-negative strategy to resolve several critical current ecological, economic and energy challenges. Properly made and used, ***biochar*** can mitigate climate change and other environmental effects:

- Sequester carbon from air to reverse global warming
- Increase soil fertility and agricultural yields
- Improve soil structure, aeration & water penetration
- Reduce use of synthetic fertilizers and pesticides
- Reduce nitrous oxide and methane emission from soil
- Reduce nitrate & farm chemicals leaching into watersheds
- Produce renewable fuels from biomass
- Convert green and brown wastes into valuable resources
- Reduce dependence on fossil fuels
- Reduce dependence on imported oil
- Support local, distributed energy production & distribution
- Create local jobs and economic cycles
- Increase community food & energy security

USDA soil scientist Dr. David A. Laird
at the National Soil Tilth Lab, Agricultural Research Service
published an article in ***Agronomy Journal*** January 2008
calling this carbon-negative ***biochar*** strategy:

A Win–Win–Win Scenario
**to Simultaneously Produce Bioenergy,
Permanently Sequester Carbon,
Improve Soil and Water Quality**

3. How is *biochar* made?

Biochar is produced when biomass is heated to 500 degrees with a minimum or absence of oxygen. Normal combustion ***oxidizes*** biomass into alkali ash, plus steam, CO_2, other gases and vapors. If air is excluded, oxygen for combustion is stripped out of the biomass, which is ***reduced*** to carbon-carbon bonds of char.

Charcoal was made for centuries around the world by simple methods with few or no tools. Small batches can be homemade with simple bucket or barrel burners. Modern ***gasification*** and ***pyrolysis*** technology uses controlled combustion in air-tight retorts to process tons of biomass into energy, gases and liquids.

4. Can *biochar* support sustainable agriculture?

Biochar enhances soil in numerous ways. Its use in soil is new, exciting and not well understood yet. ***Biochar*** isn't a fertilizer, or food source for plants or microbes. Understanding its action requires a paradigm shift from chemical views to emerging 21st Century insights into the biology of the soil food web.

Recently, scientists in Amazon rainforest found that 4,000 years ago tribes used ***biochar*** to create highly fertile ***terra preta***. Japanese used ***biochar*** in soil successfully for centuries before it was displaced by industrial chemicals.

New research shows ***biochar*** has several effects in soil:

- increase water infiltration and water holding capacity
- improve soil structure, tilth and stability
- increase ***cation*** exchange capacity (CEC)—and also ***anions***
- adsorb ammonium, nitrate, phosphate, and calcium ions
- greater nutrient retention than ordinary organic matter
- improve soil pH buffering and stability
- increase soil biology & diversity, creating a ***microbial reef***
- provide refuges for mycorrhizae & nitrobacteria
- better, denser root development
- reduce fertilizer runoff, especially nitrogen & phosphorus
- reduce total fertilizer requirements
- 50-80% decrease soil emissions of nitrous oxide

5. Does *biochar* increase crop production?

Research consistently finds poor soils enriched by ***biochar*** grow bigger, stronger plants that yield higher quantity and quality. Yields 300% greater are common, and some researchers got over 800% more yield from ***biochar***-enriched soils.

Even better, soils retain nutrients and sustain productivity better than soils without ***biochar***. Plants grow well in soil with 9% ***biochar***, at less cost, increased yield, and sustain this greater production longer with less fertilizer. Food from those soils has higher nutritional balance, density and quality.

In soil, ***biochar*** consistently increases fertilizer efficiency, reduces need for chemicals, enhances crop yield. As examples:

- A Mississippi farmer plowed 15 tons/acre ***biochar*** into sandy river bottom, and saw corn yield over twice his neighbors. After the first year, his fertilizer use declined.

- Australian research in New South Wales added 4.5 tons/acre to carbon-poor soil to double soybean biomass, triple wheat.
- Tomato transplant trials in 2008 at Virginia Tech with a cup of ***biochar*** in a gallon of soil mix averaged 48% more yield.

Field observations reveal ***biochar*** reduced need to irrigate.

Crop response is enhanced when ***biochar*** is inoculated by beneficial micro-organisms to increase nutrient use efficiency, and trace elements to boost full spectrum health and vitality.

Northern gardeners find ***biochar*** darkens soil, so in spring it warms sooner, to allow earlier planting and grow stronger roots.

6. How is *biochar* applied to soils?

Biochar can be broadcast, or applied by drop spreaders.

On corn, soybean and similar row crops, drop ***biochar*** with seed in furrows to support growth when seeds germinate.

Biochar blended with compost and mineral fertilizers rapidly improves microbial diversity and shortens crop response time.

Biochar's capacity to hold water and nutrients make it an excellent addition in potting soil mixes.

7. Does *biochar* replace compost?

Biochar is different than conventional organic matter created by decay of plant and animal waste. While ***biochar*** is a substrate for microbial cultures, fresh ***biochar*** is bone dry and sterile, and must be inoculated with compost, compost tea or other cultures.

8. Can *biochar* reduce greenhouse gas levels?

Carbon in ***biochar*** resists degradation, decay and digestion, and can sequester carbon in soils hundreds to thousands of years.

Photosynthesis unites CO_2 with water to make carbohydrates, or sugar. If ***biochar*** is made in a burner, some carbon returns to the air as CO_2, but 20 to 60% of the carbon remains as ***biochar***.

In soil, ***biochar***'s carbon-carbon bonds don't break down, and stay in soil for centuries. So, CO_2 fixed by photosynthesis is now an inert form, safely stored long-term.

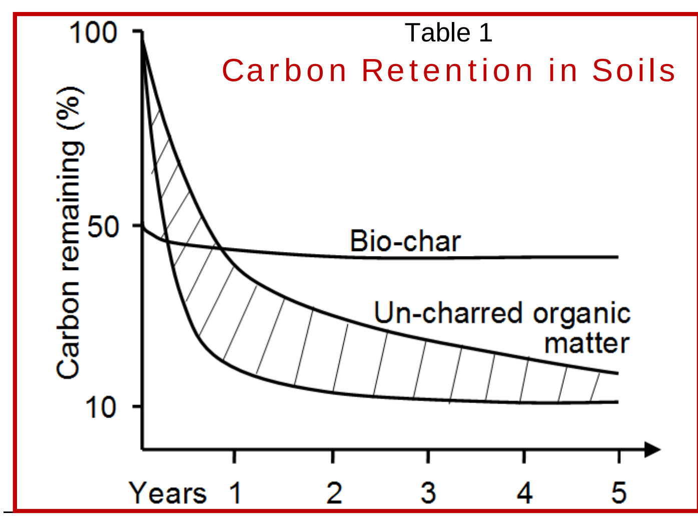
Thus, ***biochar*** in soil is a true carbon-negative strategy.

Biochar remains in soil far longer than other organic matter, such as compost, plant residue or manure that oxidize quickly. ***Biochar*** is one of our few ways to permanently sequester carbon.

Robert Brown at Iowa State University, with a $1.8-million USDA grant, calculates corn stalk ***pyrolysis*** into ***biochar*** on a 250-hectare farm can sequester 1,900 tons of carbon a year.

NASA climate scientist **James Hansen**'s August 2008 paper estimates that applied worldwide, soil sequestration by ***biochar*** can lower CO_2 by ~8ppm in 50 years.

Research also shows adding ***biochar*** to soils reduces nitrous oxide emissions by 80% and eliminates methane emissions—far



worse greenhouse gases than CO_2.

In soil, ***biochar*** improves fertility to stimulate greater growth, which fixes more CO_2. Each year's harvest of biomass is larger, to convert to more biofuel and biochar—to build fertility each year—nature's positive feedback cycle.

Biochar by modern controlled ***pyrolysis*** is an approved Clean Development Mechanism in the UN Framework Convention on Climate Change to avoid methane from biomass decay.

Currently, ***biochar*** earns no credit on any carbon exchange as a way to sequester carbon. However, as 2008 ends, proposals were presented at a series of international climate deliberations.

9. Can *biochar* produce renewable energy?

Biomass is the world's third largest fuel, after coal and oil. Most biomass is woody matter, green wastes, crop residues, food processing wastes (eg. rice husks). Current biomass-to-energy technology is at best *carbon neutral*, and isn't sustainable, since harvests deplete nutrients, reducing fertility and productivity.

Pyrolysis making ***biochar*** also produces energy. As biomass breaks down into char, hydrogen, methane and other hydrocarbons are released and captured to refine into renewable fuels. Energy produced making ***biochar*** can be turned into space heat, electricity, reformed into ethanol or ultra-clean diesel.

One ton of biomass can equal 5.5 barrels of oil. ***Pyrolysis*** uses wastes, and about half the original carbon and most minerals are returned to the soil, where they support sustainable, biological fertility. ***Biochar*** sequestration is our best chance to turn energy production into a carbon-negative industry.

National Renewable Energy Lab research concluded that each gigajoule of hydrogen produced stores 112 kg of CO_2 in soil.

10. Can *biochar* create energy independence?

Biomass ***pyrolysis*** facilities can create new local businesses, jobs and financial cycles to raise incomes in rural communities.

Farming benefits, because ***biochar*** boosts soil fertility while reducing purchased fertilizers and sequestering CO_2. Farmers can use biofuel as on-farm energy, plus produce surplus energy to sell. Renewable energy and carbon credits are new revenue sources. Energy and fertilizer become decentralized, distributed, to reduce imported oil and gas dependence, and support regional energy production competitive with fossil fuels.

This carbon-negative energy production doesn't cut trees or divert food crops. Instead, crop residues and biomass wastes produce hydrogen, methane, *syngas*, electricity, bio-oils, ethanol—and ***biochar***, to renew soil and boost productivity.