Biochar:
Climate Change and Soils

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Biochar and Sustainability

Presentation Overview

- What is biochar?
- How is biochar produced?
- What makes biochar carbon-negative?
- What are the impacts of biochar?
- Impediments to production, utilization?
- The International Biochar Initiative (IBI)

What is Biochar?

- Biochar is a charcoal-like substance produced from the controlled, incomplete combustion of biomass in an oxygen-free or oxygen-limited environment.
- As a soil amendment, biochar creates *virtually permanent* carbon sinks (*MRT 1,000-2,000 yr*); dramatically improves soils; and has multiple environmental benefits.
- Biochar is a carbon-negative technology, and can remove CO_2 on gigaton scales, to combat climate change. It is one of the few carbon-negative technologies at our disposal.

What is Biochar?

- During *biochar* production, up to 50% of the biomass feedstock C is retained in the crystalline biochar structure *(Lehmann, 2007)*
- Bio-energy is a co-product (oil or syngas)
  - Thermal energy (cooking, heating)
  - Oil or gas for on-farm electricity generation
  - Oil or gas for refining, fuel production
- *Biochar* production systems are scalable, and have appropriate developed and developing country applications.

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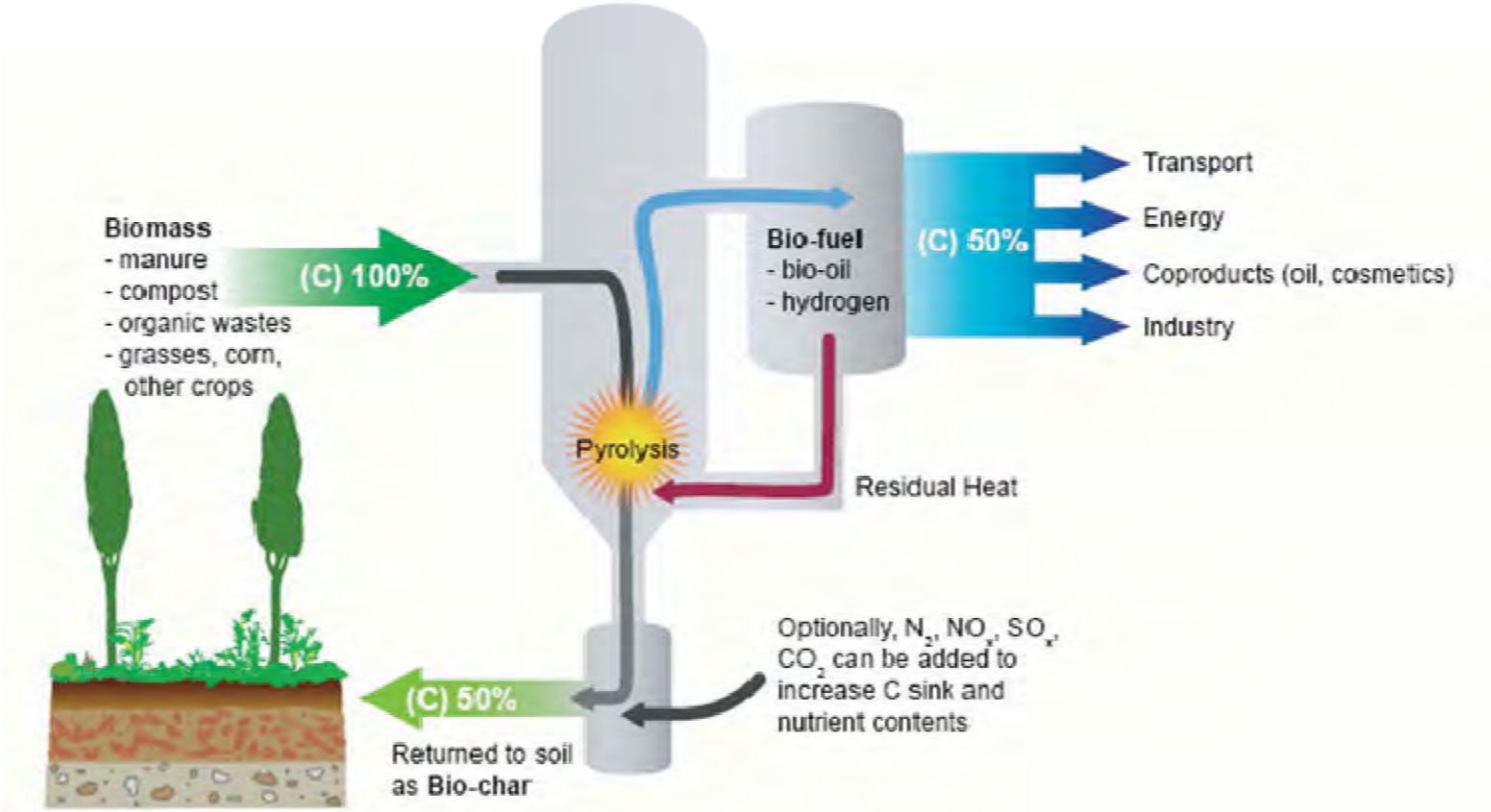
How is biochar produced?
Pryolysis of biomass



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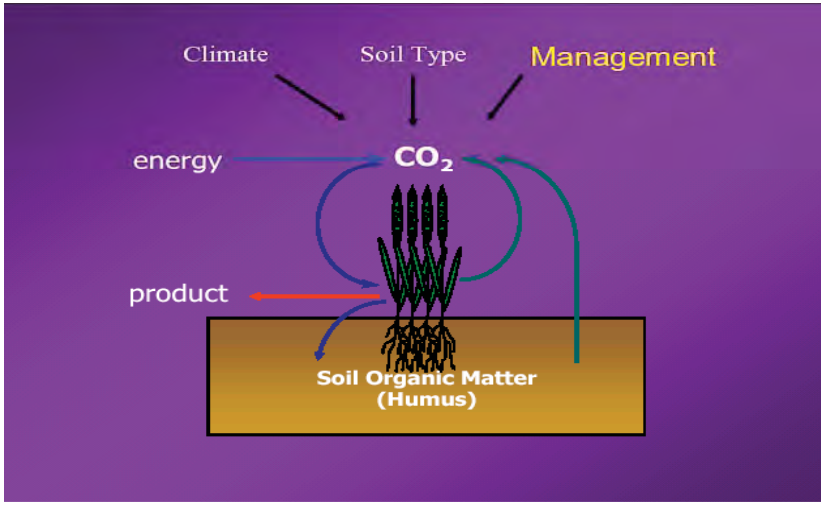
Source: Lehmann, J, *Front Ecol Environ* 2007; 5(7):381-387

What makes BIOCHAR "*Carbon-negative*"?

CO_2 Cycle (simplified): "Carbon-neutral"

- CO_2 is captured by photosynthesis and fixed into biomass
- Biomass decays into CO_2



Biochar interrupts the decay process by capturing the C in a virtually permanent carbon stock, *preventing it's re-release to the atmosphere*.

Biochar & Climate Change

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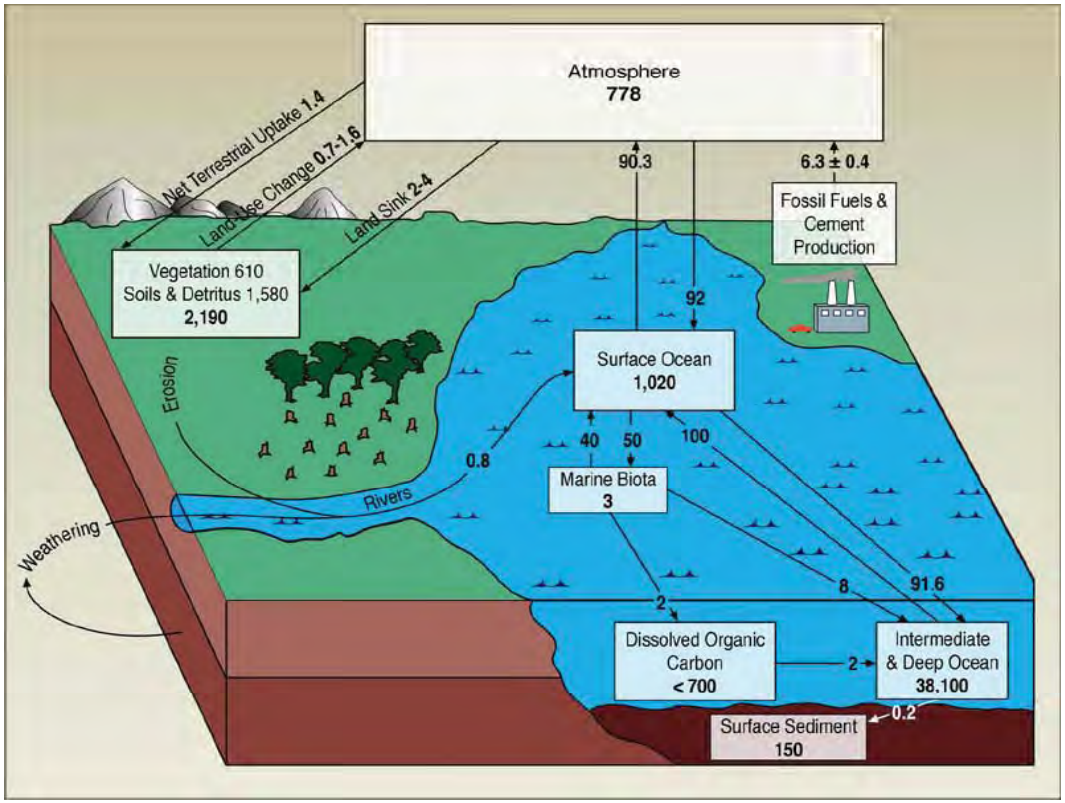
Since all atmospheric CO_2 passes through biomass every seven years, the production and utilization of biochar on a large enough scale would lead to significant negative trends in global CO_2.



C Cycle Graphic:
www.climatescience.gov

Biochar and Sustainability: Improving the Earth's Soils

- Impact of *biochar* on soils, crops:
  - Enhances nutrient retention and bio-availability to plants;
  - enhances moisture retention;
  - inhibits nutrient leaching into ground and surface waters;
  - Improves soil quality, fertility, crop productivity
  - Reduces N_20, CH_4 emissions

Some Impacts of Biochar

Air and GHG Impacts:

- Nitrous oxide emissions reduced 50-80% from cropland soils
- Methane emissions from soils surpressed
- Stable, virtually permanent* soil carbon pools
  - (*MRT 1,000-2,000 years)

Water Quality Impacts:

- Biochar strongly adsorbs phosphate
- Reduces leaching of nitrogen and phosphorus

What makes Biochar work?

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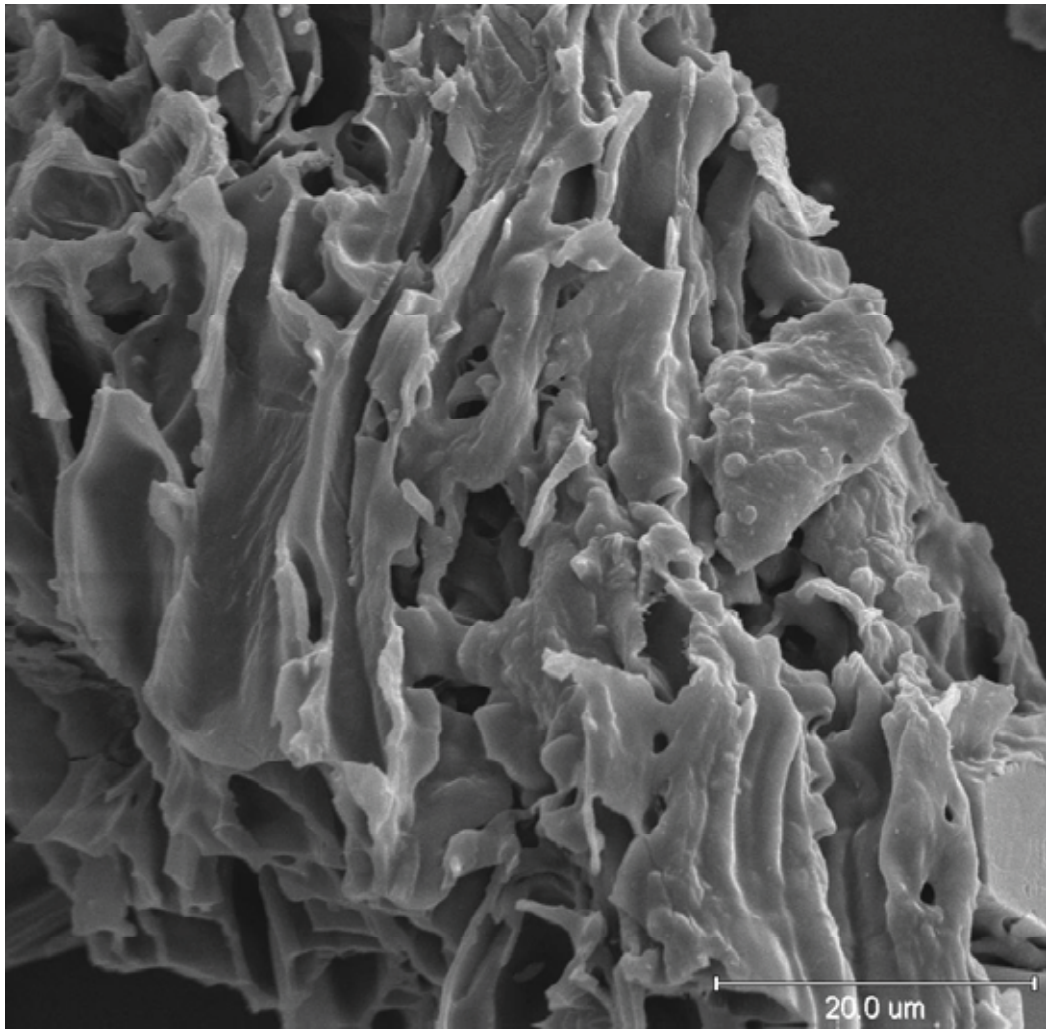
- During formation, the porous, crystalline biochar structure adsorbs bio-oils, nitrogen, phosphorus, other nutrients from feedstock
- Very high surface area
- In soil, biochar is extremely recalcitrant to decomposition
- Soil microorganisms and H_2O inhabit micropores
- Nutrient leaching and volatilization are inhibited, but nutrients are bioavailable to plants



Source: Robert Brown, Iowa State University

What Makes Biochar Work?

- Considerable R&D efforts underway
- Highly porous, high surface area is charged, supports soil microbial communities, stimulates mycorrhizal fungi in soil, which promotes plant growth
- Higher soil nutrient retention and nutrient bio-availability (related to higher cation-exchange capacity and high surface area of the charcoal)
- Biochar in soils increases above- and below-ground biomass production

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Biochar Pot Trials:

Biochar from rice husks (500°C); sterilized subsoil

Control

Biochar

Biochar + fungi

Photos: Robert Flanagan, SAFFE, China (2008)

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Terra Preta Soils: An ancient technology

- Agriculture can itself create sustainably fertile soils by producing biochar from agricultural waste biomass
- Concept: "Terra Preta de Indio" soils
- Terra Preta soils of Amazon basin contain up to 70x more black carbon than surrounding soils, and high levels of nitrogen, phosphorus, potassium, and calcium (*after 500-5000 years*)

Biochar and Sustainability: Terra Preta de Indio Soils

Terra Preta de Indio Soil

Nearby Oxisol Soil

Photos: Julie Majors, Cornell University

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Biochar and Sustainability: Climate v. Agriculture

- Sink impacts occur in all soils
- Agronomic impacts are most remarkable in degraded soils:
  - Reverting C loss increases crop yields
  - Greatest efficiency in SOC and yield increases in the most degraded soils
- Greater sustainability in SOC and yield increases with biochar

Impediments to Biochar Production, Utilization

- Economics favor energy production, not biochar production
- Competition for feedstock?
- Carbon credits, biochar markets can help
- Exact mechanics of biochar recalcitrance (sinks) yield impacts unknown (research shows unrelated to nutrient availability?)
- Biochar classification system: not one animal – spectrum (production side, also)

The International Biochar Initiative

- A *consortium* of research, commercial, and policy-oriented institutions and people devoted to sustainability of world's soils, and sustainable bioenergy production
- Formed at 2006 World Congress on Soil Science

- 1st international conference Spring, 2007 in Australia (www.iaiconference.org)
- 2nd international conference Sept. 8-10, 2008 in Newcastle, UK (www.biochar-international.org)

Biochar and the IBI:

Sustainable Biochar Production and Utilization

Biochar is a sustainable, carbon-negative technology that can remove atmospheric carbon on gigaton scales while improving the earth's soils.

- Biochar has multiple ancillary environmental, social, and development benefits;
- Biochar systems are scalable and have appropriate developed and developing country applications;
- IBI supports sustainable Biochar production and utilization systems that reduce net greenhouse (GHG) emissions on a full GHG lifecycle analysis, that do not contribute to direct or indirect land use change, and that are supported by indigenous peoples and stakeholders.

ROLE OF IBI: IBI's role is to support top-down (international, national, and sub-national governmental efforts) and bottom-up (research, science, demonstration projects, commercialization) activities to promote sustainable biochar production and utilization systems that successfully achieve biochar's potential to mitigate climate change and improve soils globally.

The International Biochar Initiative

Mission Statement

- IBI is a platform for the international exchange of information and activities in support of *biochar* research, development, demonstration and commercialization.

- IBI advocates *biochar* as a strategy to:
  - improve the Earth's soils;
  - help mitigate the anthropogenic greenhouse effect by reducing greenhouse gas emissions and sequestering atmospheric carbon in a stable soil carbon pool; and
  - improve water quality by retaining agrochemicals.

- IBI also promotes:
  - sustainable co-production of clean energy and other bio-based products as part of the *biochar* process;
  - efficient biomass utilization in developing country agriculture; and
  - cost-effective utilization of urban, agricultural and forest co products.

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www.biochar-international.org