Biochar for carbon sustainability and waste management

Stanford / Climate Foundation Biochar Team
Brian Von Herzen, Executive Director
What is Biochar?
Prehistorically Proven

Numerous catalogued prehistoric sites with anthropogenically improved soils.

The topsoil from these sites is mined and sold for ~$1/kg

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Thermophysical Properties

Highest Heating Temperature (HHT)

Cation Exchange Capacity (CEC)

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Lehmann & Joseph  Biochar Environmental Management (2009)
It’s all about H, C, N, and O

Cellulose, Hemicellulose, and Lignin can form aromatic sheets...

But how much?

\[
C_1H_{1.4}O_{0.6} \quad \text{Heat} \quad xH_2 + C_{0.6}O_{0.6} + \tilde{C}_{0.4}
\]

32% C by mass

Lehmann & Joseph
Biochar
Environmental Management
(2009)

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Why is Biochar important?

• Reduces fertilizer use
• Renders soluble nitrate fertilizer insoluble
• Reduces water use
• Reduces runoff
• Multiplies the productivity per unit fertilizer added
• Keeps nutrients near the plant roots longer
Terre Pretan soils are the most productive

Pre-Columbian (950 to 450 BC)

Lehmann et al. (2003)
BioChar + NPK vs. NPK
Can Biochar be made from human solid waste?
Urine Diverting Dry Toilets

http://envirosan.co.za/products/
Sanergy squat plate UDDT design

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Sanergy Sanitation Units
Sanergy Sanitation Unit

- Material
- Costs of
- <$200
- Per unit

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Spreading adoption of UDDTs
Saner.gy business model:
Soil Capital

- Cornell Prof. Johannes Lehmann and Dr. Kelli Roberts reported 10x benefit of soil carbon over 50 years

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Roberts et al., in revision
Biochar: black gold

- Bank account @ 3% inflation vs. biochar @ 1%
Making Biochar from HSW efficiently and with ODOR MANAGEMENT

ODOR ELIMINATION FEATURES:
1. Sub-atmospheric pressure draws air in
2. Lean burn post-combustion eliminates the odors
3. Biochar activated charcoal filter cleans the exhaust of odors,
Rendered cross-sectional view of the biochar reactor
How the pyrolyzing turntable works
Solid Waste Biochar Reactor

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Energy Budget: 60% H2O

- +8.00 MJ/kg heat generated from combustion
- -1.35 MJ/kg heat of vaporization at 60% H2O
- -0.18 MJ/kg thermal capacity to warm water
- -0.14 MJ/kg warming dry fecal solids to 100 C
- -0.52 MJ/kg heating steam and solids to 350C
- +5.81 MJ/kg remaining thermal energy remaining after HSW heating and vaporization
Syngas combustion
Syngas combustion: expanded injector nozzles
Results: NASA Simulant 51% H$_2$O
3 Kg/hr, decrease to 1.5Kg/hr

Syngas 6KW
Pilot 0.75 KW

Simulant flow
Decrease to 1.5 Kg/hr

Syngas flame
decrease
Results: NASA Simulant 60% H$_2$O
30-minute burn @ 3 Kg/hr

- Generates 300 g/hr biochar
Showcase: US Biochar 2012

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Results:
Biochar Reactor to serve thousands in urban slums

Container-based continuous flow pyrolysis with dehydration

Human Solid Waste

cool exhaust

cool exhaust

Warm exhaust

moist biomass

Heat exchange

dried biomass

gas collection system

Fast pyrolysis chamber

burner

exhaust

heating

chamber

biochar out

hopper

2009.12.09.bvh
Climate drought nations

http://3dsciencepics.com/drought-globally/

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Peak Oil in US

U.S. Crude Oil Production versus Hubbert Curve

Data source: US Energy Information Administration
BioChar Benefits

- Renewable Energy
- Permanent Carbon Sequestration
- Waste Mitigation
- Environmental Remediation
- Soil Enhancement
Biochar rebuilds soil capital with global benefits
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Reinvent the Toilet
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Biochar Sanitation Pipeline