



# Biochar Origins, Markets, Products and Processes

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*BIOCHAR AND BIOFUELS*

Bioenergy Washington

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# Biochar Origins, Markets, Products and Processes

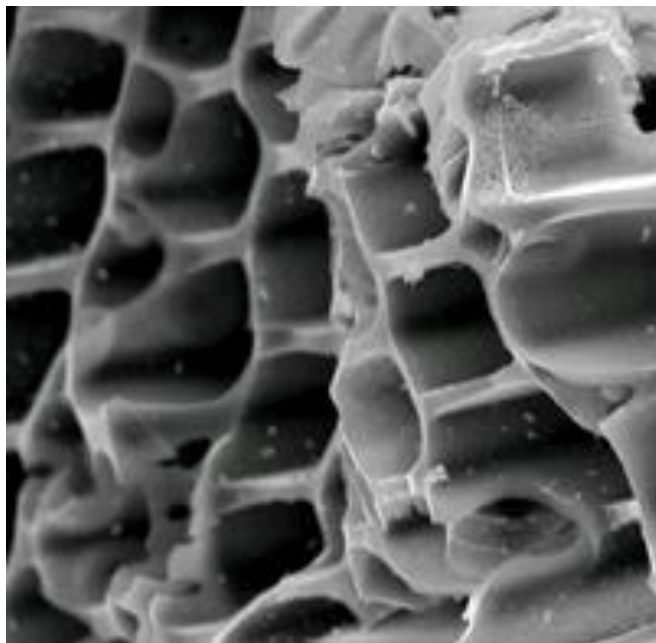
- What is Biochar
- Origins: Amazonian Dark Earth (Terra Preta)
- Products, Markets
  - Uses, Feedstocks, Qualities, Co-products
- Processes
  - Pyrolysis, Gasification
- Opportunities
  - Urban wastes, compost,
  - Coproduction of Biochar, Heat and Power

# What is Biochar?

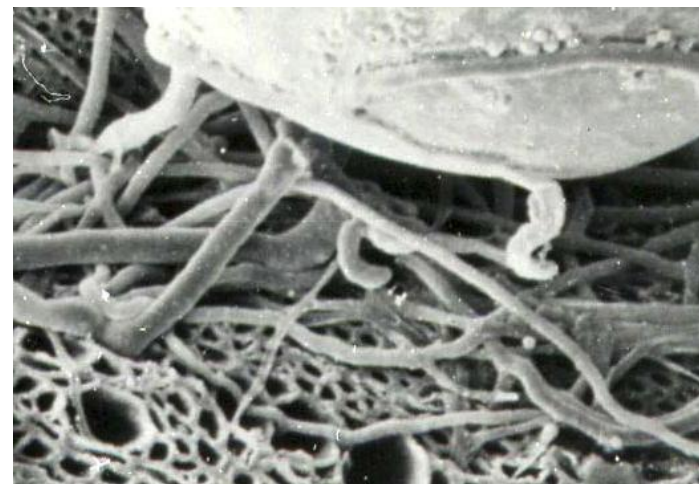
**Biochar is a fine-grained, highly porous charcoal that helps soils retain nutrients and water. IBI**



**Charcoal plant  
ICM**



**Collins 2009**



**Mycorrhizal fungal hyphae  
growing from spore base invade  
large charcoal pores**

**Ogawa 2004**



# The Origin of Biochar: Amazonian Dark Earth (Terra Preta de Indio)

- Heavy clay soils on high bluffs above Amazon river
- Low pH (3.5-4), high iron, high alumina, high leaching



International Biochar Initiative  
Brazil Field Trip, September 2010



# Charcoal and Nutrients Enriched Poor Soil

- Terra Preta Ingredients: charcoal, fish bones, food waste, excrement, soil
- Anthropogenic soil: 30 in (75 cm) pH 5-6; P 100-300x; Zn 10 x; high base sat; low Fe sat
- Crops: Manioc, papaya, mango, corn, oranges, cacao, banana, cupuaçu





# Abundant Crops Grow on Enriched Soils



No Char  
Ferralsol  
Hi Iron  
pH 3.6



Char Only  
Terra Mulata  
pH 4.4



Char + Waste  
Terra Preta de  
Indio  
pH 5.3-5.7



Papaya  
Biochar+ Fertilizer



Cupuaçu



Cacao Pod and Bean



Manioc (Cassava) root





**Ferralsol**



**Terra Preta**

IBI

***Terra Preta –  
A 2,000 year old soil experiment  
Model for sustainable agriculture***

**Mineralogy**

- Comparable texture
- Same clay mineralogy
- Rich in Fe and Al oxides

**Anthropogenic signs**

- Potsherds
- Charcoal (2000 years)

**Soil fertility**

- Nutrients
- Soil organic matter
- Stable SOM
- Cash crops

(Bruno Glaser Biochar 2010)

**BIOCHAR AMENDED SOILS HAVE HIGH FERTILITY**

# Biomass Sources and Biochar Markets

- Sources
  - Urban wood waste
  - Agricultural and Forest Industry process residues
  - Forest residues – slash, fuel reduction, restoration
  - Crop residues
- Markets
  - Horticulture, nursery and urban landscaping, community gardens
  - Turf establishment and maintenance, parks, golf courses
  - Soil remediation and storm water (green streets) nutrient management
  - Crops and soil amendment, e.g. biochar + digested solids, composting



**Inspecting Seedlings Grown with Biochar**

Soils and Use Determine  
Properties Required



# Blend biochar with soil or compost.



-1/2" hardwood biochar



Biochar compost



Roots in direct contact with biochar improve fertility and growth.



Josiah Hunt, Landscape Ecology, Hilo, HI

[www.biochar-international.org/groups/hawaii](http://www.biochar-international.org/groups/hawaii)

# Biochar Helps Grow Trees

## Agronomic Benefits

### SOIL STRUCTURE-

Vermiculite substitute

### COMPOST AID -

Peat substitute = Compost + Biochar

### PLANT HEALTH -

Inhibits root disease

Nutrient (P) carrier for poor soils



2008  
Calforest  
Nurseries



Ponderosa Pine in Soilless Media with  
Vermiculite (Left) and Biochar (Right)



# Biochar Promotes Healthier Soils and Crops

## Agronomic Benefits

### SOIL STRUCTURE-

Amend root zone

Increase porosity, WHC, CEC

Reduce compaction

### PLANT HEALTH -

Inhibit root disease Pythium, Fusarium

### ENHANCED ROOT GROWTH

Frankia Sp. N fixing

### NUTRIENT FILTER -

Capture, use, NPK

### ESTABLISHMENT

Seed coating

Microbe Carrier



0% biochar on left,  
20% biochar on right



Corn in poor soil (Left) and  
Biochar Amended Soil (Right)

# Biochar Can Improve Turf and Landscape Management for Parks and Recreation

- Use normal practices
- Use stable soil amendment
- Retain more water
- Replace non-sustainable materials
- Reduce chemical leaching and runoff
- Reduce chemical and fertilizer use
- Decrease saturated hydraulic conductivity
- Promote growth of microorganisms
- Sequester CO<sub>2</sub>

(Sunmark Environmental)



Biochar can resist Pythium blight  
(Photo LP Tredway)



# Biochar Improves the Environment

- Reduce nitrous oxide emissions 50-80%  
(Rondon, Ramirez, and Lehmann, 2005)
- Reduce phosphorus and nitrogen in groundwater
- Increase soil carbon- reduce atmospheric CO<sub>2</sub>
- Reduce forest fuel load
- Revitalize Brownfield sites
- Sequester carbon



# Biochar Improves Remediation



“This was the recycled nasty soil from the steel mill that still grew vegetation. There is a line of where we sprayed PermaMatrix and where it was not applied. The other vegetation died.”  
-- Drew Schaefer Sunmark Environmental [www.sunmarkenvironmental.com](http://www.sunmarkenvironmental.com)



# Biochar Improves Stormwater Cleanup



Biochar in filtration mix



A roof drain tote built  
for *zinc* removal



Improved storm water quality

Sunmark Environmental

# Biochar Aids Revegetation



Jory clay cut slope where nothing had grown for 10 years.



After revegetation with PermaMatrix and biochar.

Sunmark Environmental



# Make Biochar Suited to the Application



1/2" minus hardwood biochar ([www.landscapeecology-hawaii.com](http://www.landscapeecology-hawaii.com))

# Feedstocks and Process Conditions (Heat)

## Determine Biochar Properties

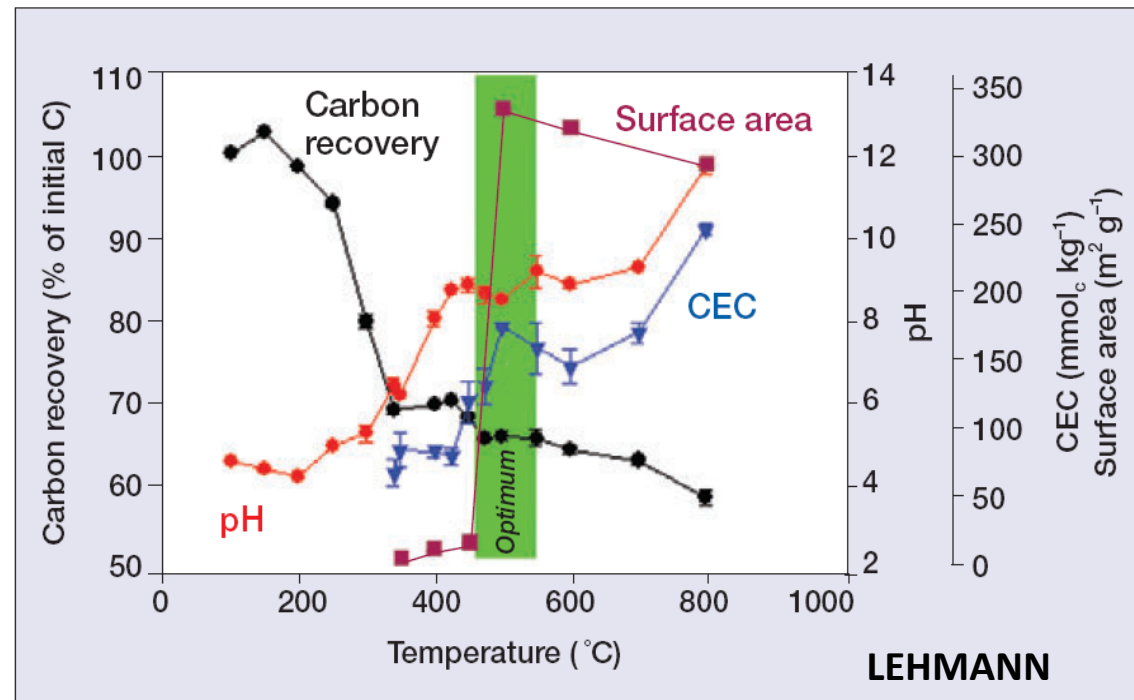
High temperatures -> Low yield, high pH, high CEC, high surface

Low temperature -> High yield, mid pH, mid CEC, high surface



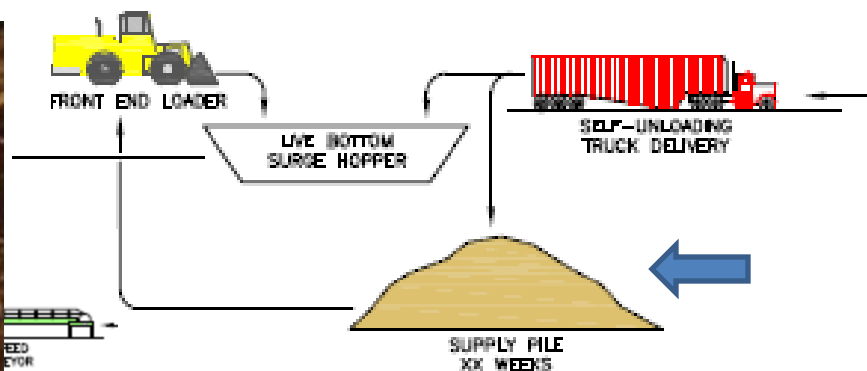
70-80% Gas

20-30% Char



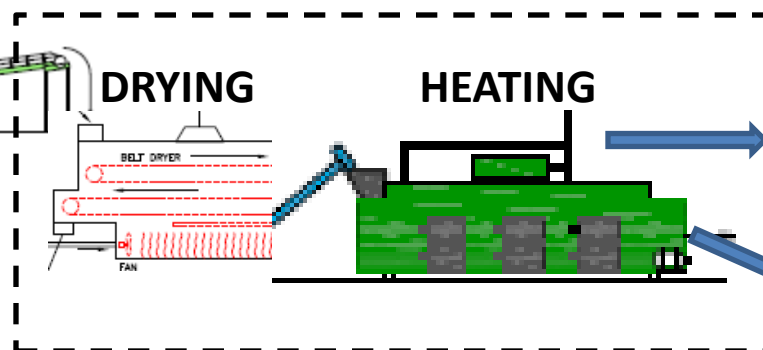
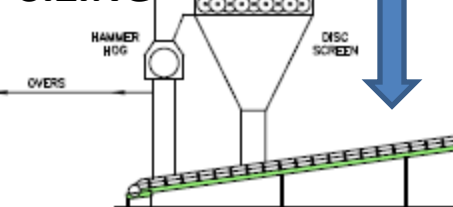


# Biochar is an Industrial Process



**GRIND BIOMASS**

**SIZING**



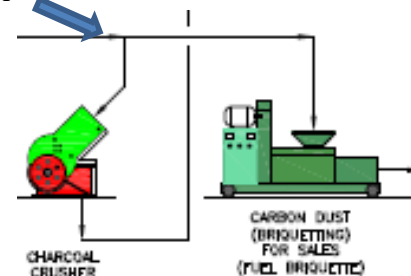
**GAS TO  
HEAT OR  
POWER**



**BIOCHAR  
SCREEN**

**Pyrolysis: 3 DRY TON BIOMASS--> 1 TON BIOCHAR +  
16 MMBtu (1 MWhe)**

**Gasification: 8 DRY TON BIOMASS->1 TON BIOCHAR +  
100 MMBtu (6.3 MWhe)**



**GRIND**

**DENSIFY**

# Biochar Is Made at Small and Large Scales



**BioChar TLUD Cook Stove**  
Seachar.org

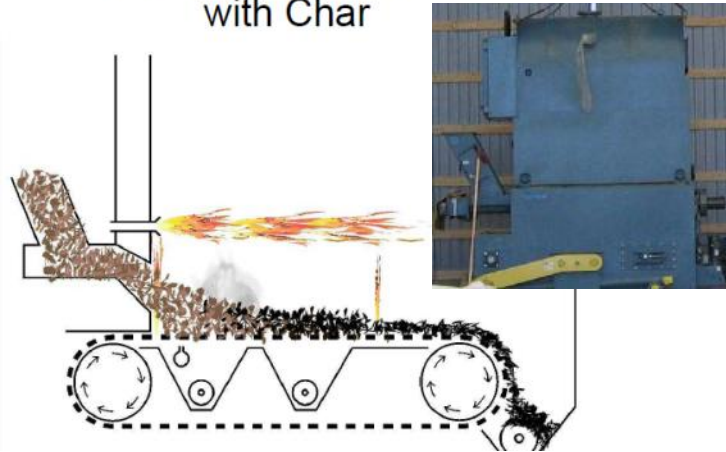


**Greenhouse scale heat and  
biochar NE Biochar 1 t/10h**



**Mobile Pyrolysis**  
**Black is Green (BIG) AUS**

Two Stage Combustion  
with Char



**Burt's Greenhouses**  
**Ontario, CAN**



**Boiler 3 MMBtuh Hot Water**  
**500 lb/h 25% Char**



**ICM Gasifier**  
**4-8 tph**

T R Miles Technical Consultants, Inc.



# Small Scale Biochar for Greenhouse Heat and Char



**Adam Retort (Pakistan) 1 T Batch**  
[www.biocoal.org](http://www.biocoal.org)



**New England Biochar Reactor 1 T Batch**  
Heat recovery for 5,000 ft<sup>2</sup> greenhouse  
[newenglandbiochar.org](http://newenglandbiochar.org)

# Chips to Biochar and Heat



500 lb hr 5 TPD  
1,000 BDT

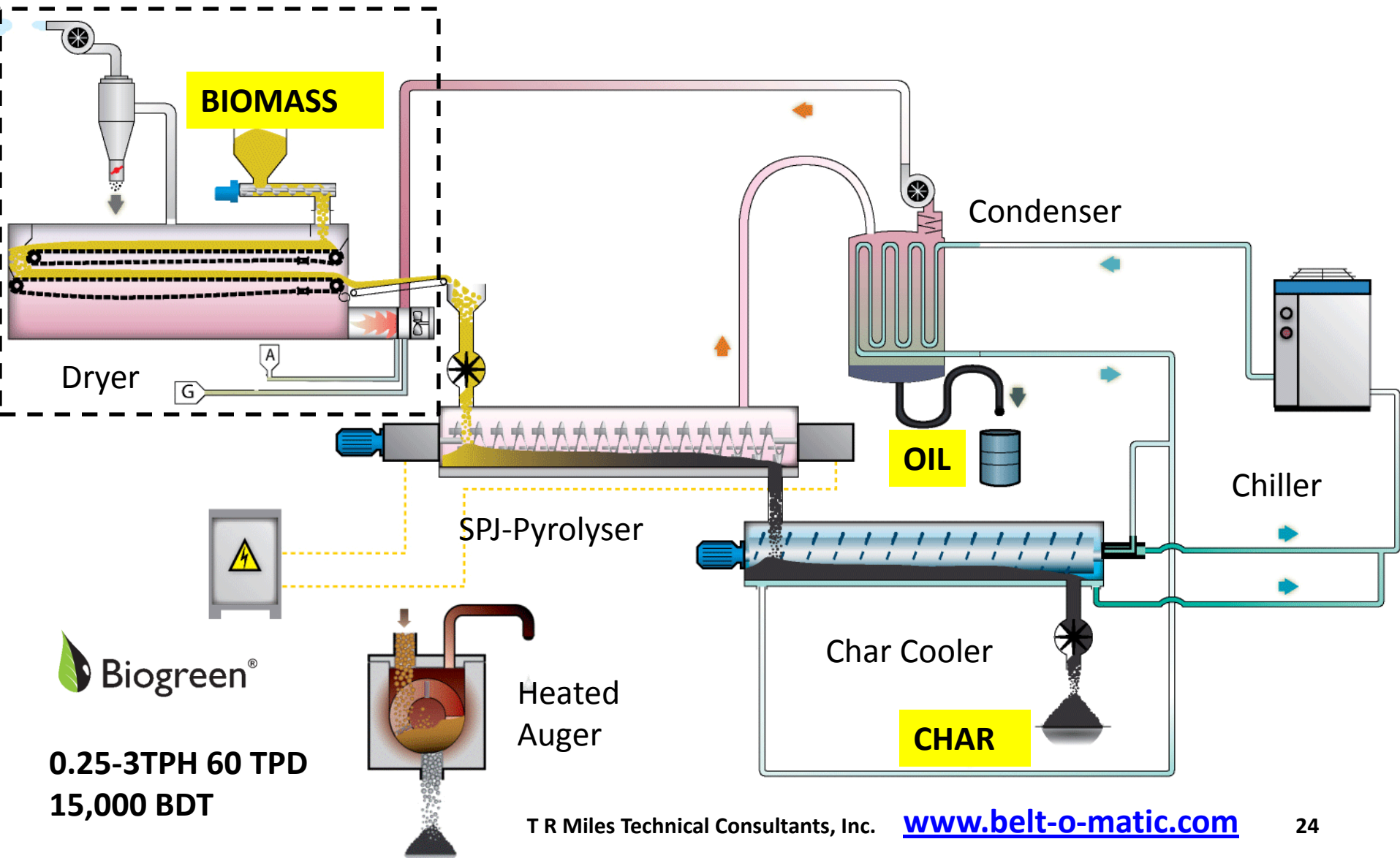


Prototype Gasifier and Carbonizer  
Thompson Timber , Philomath, OR



John Miedema

# Making Biochar and Oil: Biogreen Spirajoule Pyrolysis







Biogreen Demonstration  
Ames, IA 2010



# Small Scale Pyrolysis Systems In Development



**Mobil Demo System  
25-75 tpd 20,000 BDT**

**During Emissions Tests  
Heated Augers**

***JF Biocarbon Systems  
jovick@telus.net***



# Wood/Straw to Heat, Power and Biochar



**4-8 TPH 2-5 MWe  
30-60,000 BDT**

**ICM 200 tpd Gasifier  
Wood, Straw, Stover  
[www.icminc.com](http://www.icminc.com)**



# Biochar Can Be Made From Different Feedstocks



**Urban and Forest Wood**



**ICM GASIFIER**



**Wood Char**



**Wheat Straw or Corn Stover**



**Straw Char**

[www.icminc.com/services/gasifiers](http://www.icminc.com/services/gasifiers)



# Convert Urban, Ag and Forest Resources to Biochar and Energy to Improve Ecology and Sustainability

- Abundant Urban Residues
  - Yard Debris, Food Waste, Land Clearing Debris, Biosolids and Agricultural Waste
- Biochar is Compatible with Existing Composting, Chipping and Recycling
- Good Existing Infrastructure for Ag, Forest and Industry residues.
- Growing knowledge of biochar in the region (WSU, Seachar.org, PNW Biochar Initiative)

# Biochar Demonstrations Can Help The Community Participate in Sustainability



West Seattle Herald

***Seachar.org* Carbon Garden Project at South Seattle Community College**



# Seachar.org Carbon Garden Project (Aug 2010)





# Useful Resources

- International Biochar Initiative
  - [www.biochar-international.org](http://www.biochar-international.org)
- US Biochar Initiative – [www.biochar-us.org](http://www.biochar-us.org)
- PNW Biochar Initiative –
  - <http://groups.google.com/group/pnw-biochar?hl=en&pli=1>
- Seachar.org – [www.seachar.org](http://www.seachar.org)
- Fourth Corner Nursery, Bellingham
  - *Charcoal, Agriculture and Climate Change, Richard Haard*
  - <http://www.fourthcornernurseries.com/Article16.asp>
- [www.biochar.bioenergylists.org](http://www.biochar.bioenergylists.org)







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**Design and development of energy and environmental processes**

### **Industries**

**Biomass energy**

**Pollution control**

**Materials handling**

**Feed, Food and Fuels**

