Community Scale Biochar:

Systems and Best Practices

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Part 1: Introduction

What is Biochar?

- Carbonized biomass (charcoal) – *produced for use in the soil*.
- Valued for its high porosity and resistance to degradation
    - High porosity
        - 1 gram of properly made char has surface area of 2 tennis courts
        - Harbors the organisms that perform nutrient cycling process
        - High Adsorption capacity
    - Resistance to degradation
        - Some estimates have estimated 1000 year half life
        - Life cycle analyses underway

Advantages of Biochar Production

- Multitude of benefits in the soil (and more), Carbon Negative, Adaptable cogeneration

Application in the soil

- Porosity creates habitat for microorganisms, increasing diversity in soil food web
- Less prone to nutrient leaching
- Cation Exchange Capacity (CEC) – vastly improved nutrient uptake/exchange
- Improves soil texture, water retention.
- Aids mycorrhizae fungi
- Improves water quality
- Filters heavy metals, toxic compounds
- Increases food security in places with depleted soils
- Very long life in soil – hundreds to thousands of years
- Acts as a liming agent

Terra Preta – Pockets of ancient fertile soils within the Amazon's infertile red clay. Known to be formed as early as 450 BC, Terra Preta is an anthropogenic blend of char, with manure, bone and more. Some pockets of rich black soil are found to be six feet deep in an area otherwise known for poor quality soil.

It is said that American's too have their own 'Terra Preta'. Plains' Indians regularly performed open burns on Midwestern soils, creating a legacy of fertility we still benefit from today. Char is now known to have been used by many native peoples across the planet.

Advantages of Biochar Production (cont.)

Carbon negative

- Carbon Cycle:
  - Carbon Dioxide is absorbed from atmosphere through photosynthesis
  - Decomposing biomass releases greenhouse gasses.
  - **Pyrolysis** intervenes in decomposition stage
  - Biochar application fixes portion of this carbon in soil
- Variability of feedstock options.
  - Industry waste/residues: Slabwood, mill waste, sawdust
  - Forestry residues: Tops, culls, slash
  - Agricultural residues: Rice Hulls, nutshells, coconut shells, animal manure etc
  - Storm and Landscaping waste
  - Anything carbon based is possible

Cogeneration

- Production processes typically yield co-products
  - Condensate: Wood vinegar, oils, tar
  - Syngas: combustible gas
  - Process Heat
- 'Community Scale' systems become adaptable for combined heat and power

Disadvantages

- Not for all soils. Not for all crops.
- Raises soil pH
- Char MUST be 'conditioned' before application: or risk much lower first year yields
- Ancillary tasks amount to labor intensive, often messy process
- Still fairly expensive to produce
- Indiscriminate use and production creates a wide range of problems

Part 2 – Production Principles

Pyrolysis

- Decomposition of organic material in the absence of oxygen
- Biochar production: must reach temperatures between 400 and 500 degrees Celsius. 850 F.
- Carbon remains, volatiles release in the form of gas.
- **Endothermic** process: Requires Heat Input
- *Becomes* **Exothermic** process: Heat Output
- Process used in other industries: coal/coke production, chemical waste disposal
- Slow Pyrolysis: optimum for Biochar. What we're talking about here
- Fast Pyrolysis: optimum for bio-oil production

Combustion

- Visible flame is burning wood gas
- Requires Oxygen Input
- Creates Heat, Creates Draft
- Pyrolysis of biomass creates large amounts of gas - that must be burned clean.
- Requires maintaining high temperatures
- Preheated Oxygen allows greater efficiency

Co-Products

Syngas

- AKA Producer gas, wood gas
- Combination of combustible gasses:
- Carbon Monoxide (15-30%), Hydrogen (10-20%) some Methane (2-4%)
- Carbon Dioxide, Water Vapor and Nitrogen (45-60%).
- Usually less than half the potency of natural gas
- These numbers are representative of typical gasifiers.
- Retort gas is likely richer, with much less nitrogen, carbon dioxide and more water vapor.

Condensate

- Wood Vinegar, 'Bio-Oil', Tar/Pitch at Varying Fractions
- Wood Vinegar (pyroligneous acid)
    - High in acetic acid content, many compounds
    - Proven as herbicide, fungicide, fungal food, germinator at different dilutions
    - Preliminary trials show promising as inoculant, esp. woodland blends
    - Important in 19th century pre-petro-chemical industry. See: "Destructive Distillation"
- Bio-Oil
    - Fast-pyrolysis systems are optimized for oil production.
    - As heating oil, currently not able to replace diesel.
- Tar/Pitch
    - Avello Bio-Asphalt

Heat

- Direct
    - Pre-drying incoming feedstock
    - Carbon dioxide rich flue gas 'pumped' into greenhouses
- Via Heat Exchange
    - Many ways to do this.
    - Pickup heat at condenser, pickup heat at flue
- Best method can efficiently handle bursts

Challenges to production

Dangerous

- **Don't allow your homemade system to pressurize**
- Expand on your usual precautions when working with fire.
- Long term exposure to dust, concentrated wood gasses (carbon monoxide!), tars

Challenges to Production (cont.)

Ancillary Tasks

- Feedstocks: sourcing, transport, pre-drying
- Retorts: loading, unloading
- Processing: grinding, screening, storing
- Conditioning: mixing, inoculating
- Maintenance and Labor intensive

Conditioning

- A process that can't be ignored.
- Some tips:
    - Learn to make compost tea and soak char
    - Inoculate with mycorrhizal fungi
    - Blend with rich compost, worm castings, fish emulsion
    - Avoid compost high in salts
    - Char has a drying effect on anything you blend in
    - Particle size has varying benefits for certain applications

Bob's 4 Rules of Producing Biochar:

1. Make the very best Biochar:
2. Make as little pollution as possible (no *visible* pollution)
3. Make use of as much of the process energy as possible
4. Make a profit: Through sales, better vegetables, clean heat energy, environmental stewardship, however you choose… Just make it *worth it*

Part 3: Systems

Traditional methods

- Pits and mounds
- 10-20% efficient.
- Very slow: days to weeks process time
- Requires constant attention in a smoky environment

Backyard Biochar

- Tin Man
    - 55/30 gallon drums
    - Small batch
    - Manageable for one person, close by
    - Feedstock: sticks
- TLUD
    - Doubles as a cooking stove, some commercial versions available
    - Can be left alone for short times
    - Feedstock: twigs

The Adam Retort

- Appropriate Technology champion design
- Uses local materials, employs locals on a commercial scale
- Fill closed chamber (retort) of woody biomass. (except for one exit for gasses)
- Start generating heat at firebox, pass heat through channels underneath retort
- Syngas generated at retort exits into firebox
- “Reburned” gasses pass through channel again, exit at flue
- Doubles efficiency of traditional methods. *Less* deforestation
- Cuts down load times to 10 hours

New England Biochar Design

- Expands on Adam retort design
- Gasifier in lieu of firebox – higher temperatures, complete combustion
- Batch system, multiple batches off one charge possible w/network flue
- Indirectly heated, also direct heating option
- Forced air and forced gas. Can be run without fans, not ideal
- Steel construction makes more possible: condenser, heat exchanger, valves
- Temperature monitoring equipment: complete reaction every time
- Single batch 8-10, doubles in 12, triples in 16 hrs. 1 batch=1 yard
- Dry feedstocks: Chunked, split or sawn
- Won’t work with feedstocks prone to compaction.

Genesis CR-2 Continuous Feed Design

- Grant funded project, low hours on machine, sold to New England Biochar
- Feedstock is much different now: <1/2” particle size.
- Dry sawdust ideal, farm residues possible
- Potential for much larger throughput
- 2 stage process includes pre-drying of feedstock with flue gas
- Gas can be redirected to condenser, afterburner, pre-dryer
- Designed to run on pressure equilibrium - where no valves are necessary