Could wood fired boiler ash be considered a biochar?

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What is Biochar?

- Solid residue remaining after the heating of organic materials without oxygen

Easily degradable (0-5 yrs)

Pyrolysis

"Recalcitrant" carbon
(charcoal)
(>10 to 1,000,000 yrs?)

Pyrolysis

- Pyrolysis is the chemical decomposition of an organic substance by heating
  - Does not involve reactions with oxygen
    - typically in the absence of oxygen
- Pyrolysis is also used in everyday activity – Cooking → roasting, baking, frying, grilling
- Also occurs in lava flows and forest/prairie fires

Wide Spectrum of Pyrolysis

Both temperature and time factors:

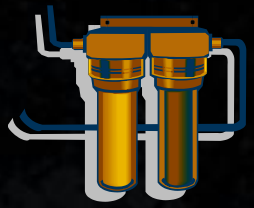
- High temperature pyrolysis
  → gasification (>800 °C) {+ O_2 }

- "Fast" or "Slow" pyrolysis (300-600 °C)
  - Fast pyrolysis
    - 60% bio-oil, 20% biochar, and 20% syngas
    - Time = seconds
  - Slow pyrolysis
    - Can be optimized for char production (>50% biochar yields)
    - Time = hours

Biochar

- Gaining significant attention:
  - Carbon Storage
    - Biochar can store atmospheric carbon, potentially providing a mechanism for reduction in atmospheric CO_2 levels
  - Soil Improvements
    - Improve water quality
    - Improve soil fertility
    - Reduce GHG emissions
  - Bioenergy

Charcoal Timeline



1000 AD

1800's

10,000 BC

5,000 BC

1000 BC

2010 AD

1700's

10,000 (?) BC – charcoal in cave drawings

3000-4000 BC – charcoal as fuel

2000 BC – first filtration use of charcoal

1908 – degradation of charcoal by fungi

1940-1950 – charcoal powered car in China

2000's – "Biochar"

Biochar

- Not a “new” idea
- Pre-Columbian Period (1,400 – 14,000 yrs ago)
  - Amazonian Natives:
    - Hypothesis : biochar was used to increase soil productivity (oxisols) by smoldering agricultural waste
      - Potential source of “Terra Preta” (dark) soils

What has changed?

- Pyrolysis, carbonization, and coalification are long and well establish conversion processes with long research histories
  - **Except:**
    - Prior emphasis:
      - Conversion of biomass to liquids (bio-oils) or gaseous fuels and/or fuel intermediates
      - Solid byproduct (biochar) has long been considered a "undesirable side product" (Titirici et al., 2007)

- Now solid byproduct is viewed with
- carbon sequestration potential (climate change)

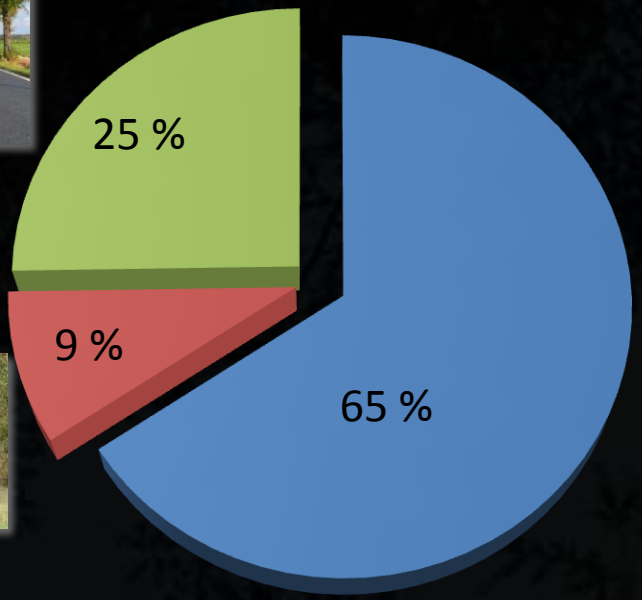
Byproducts from the Paper Industry

Large sources of biomass residuals:

- **Waste water treatment plant residuals**
  - **~ 6 million ton yr^{-1}**

- **Boiler wood ash**
  - **~ 5 million ton yr^{-1}**

Current Boiler Wood Ash Management



Estimates have been as high as 90% to landfill

•In the NE US: 80% is land applied and 5% composted with sewage sludge (85% beneficial reuse)

Greene (1988), Campbell (1990) and Vance (1996)

Direct Wood Ash Application

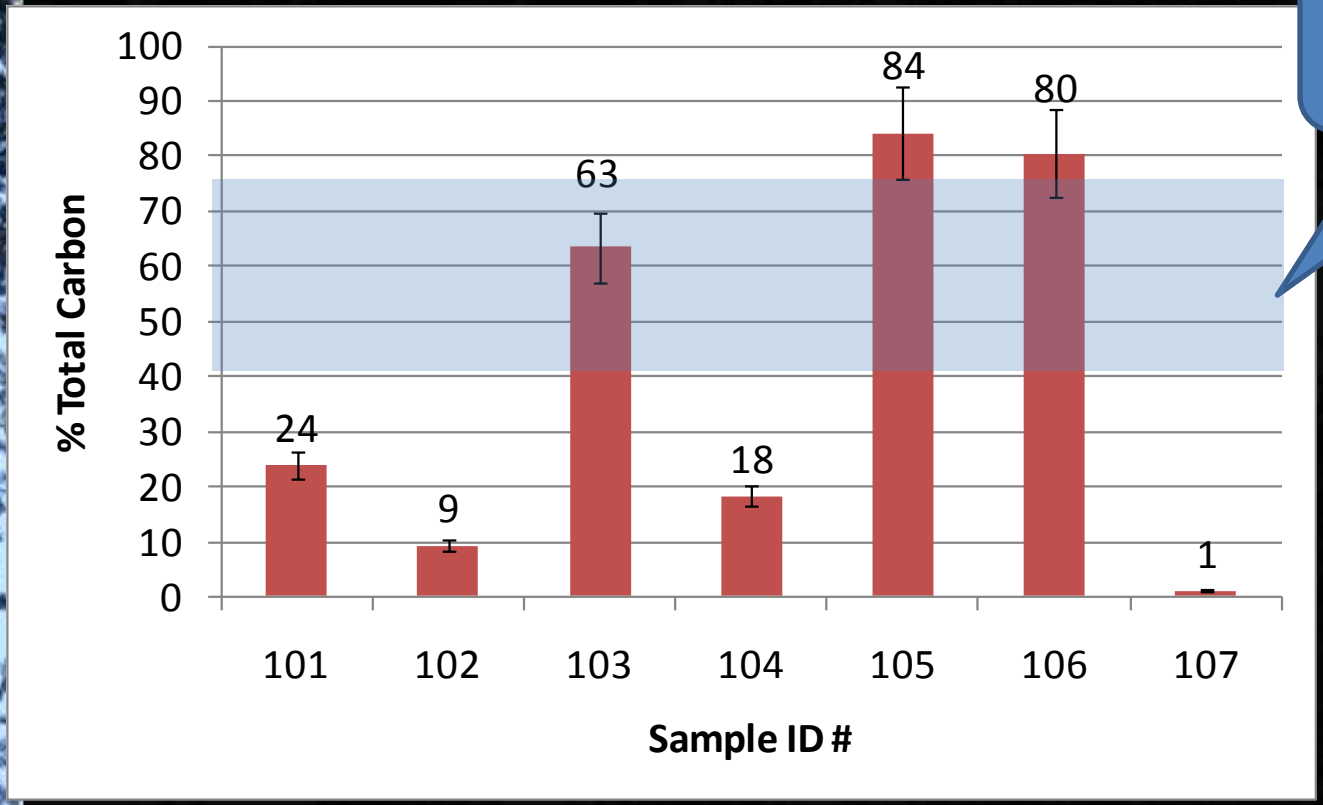
- Numerous agronomic studies have been conducted:
  - Overall beneficial effects observed:
    - Increased yields
    - Liming potential (increase soil pH)
    - Other purposes:
      - Sewage amendment, scrubber systems, cement products (Greene, 1988) and for road building (Ostrofsky,, 1983)
      - Used in Finland since 1935 as a soil amendment (Hakkila, 1989; Korpilahti et al., 1999)

- Similar results obtained in the “biochar” area

Project Overview

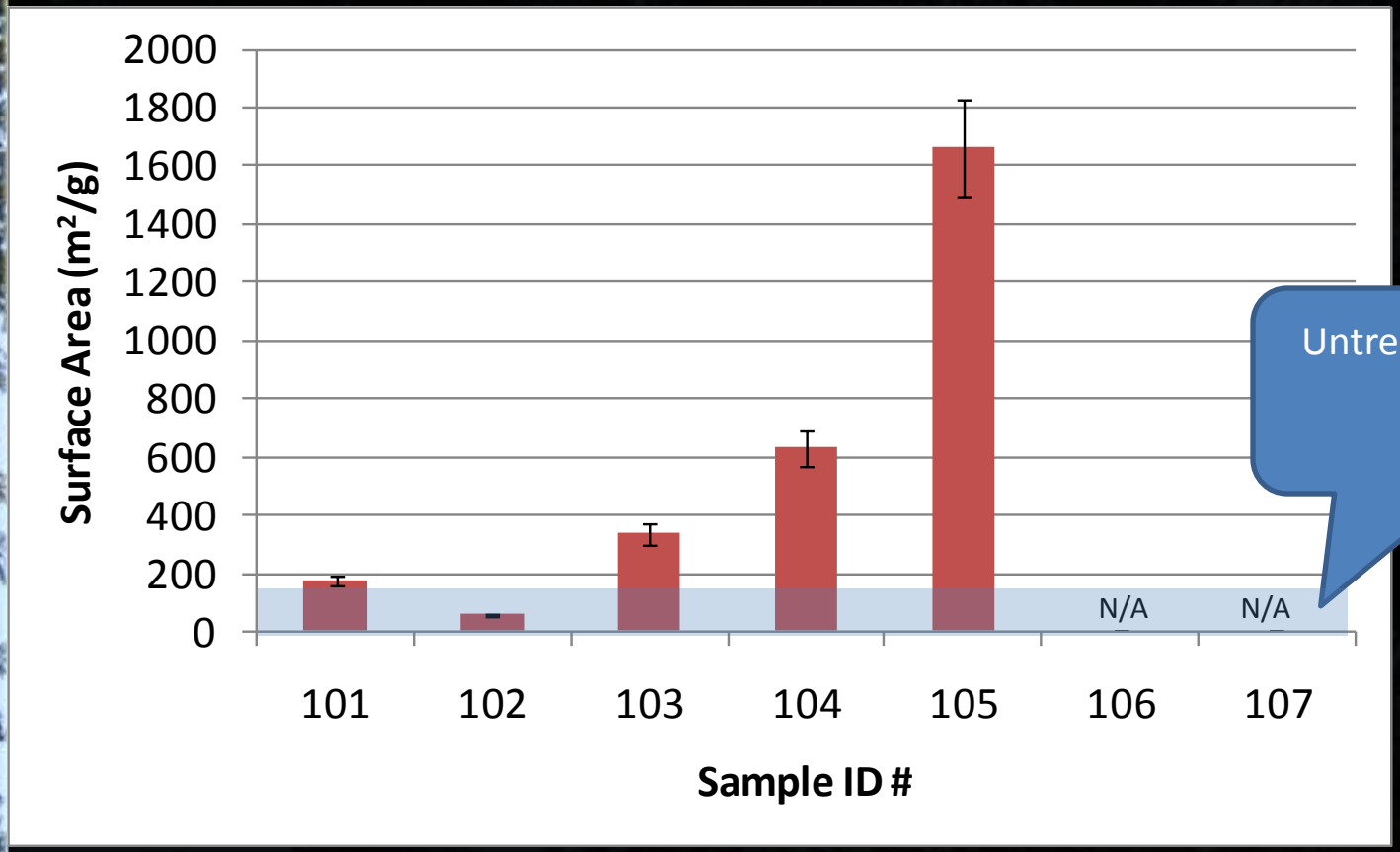
- Examining a limited number of wood boiler ash samples for their potential use as a "biochar" material
  - Moving the focus to carbon sequestration
  - Seeking to identify conditions and factors that optimize the residual C content in ash samples

Wood Ash Characteristics



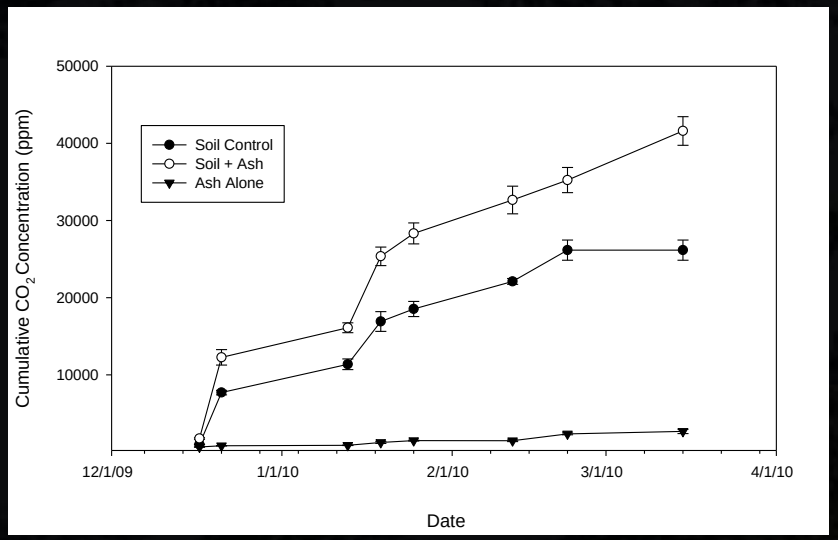
Untreated biochars:
40 to 75 % C

Specific Surface Area

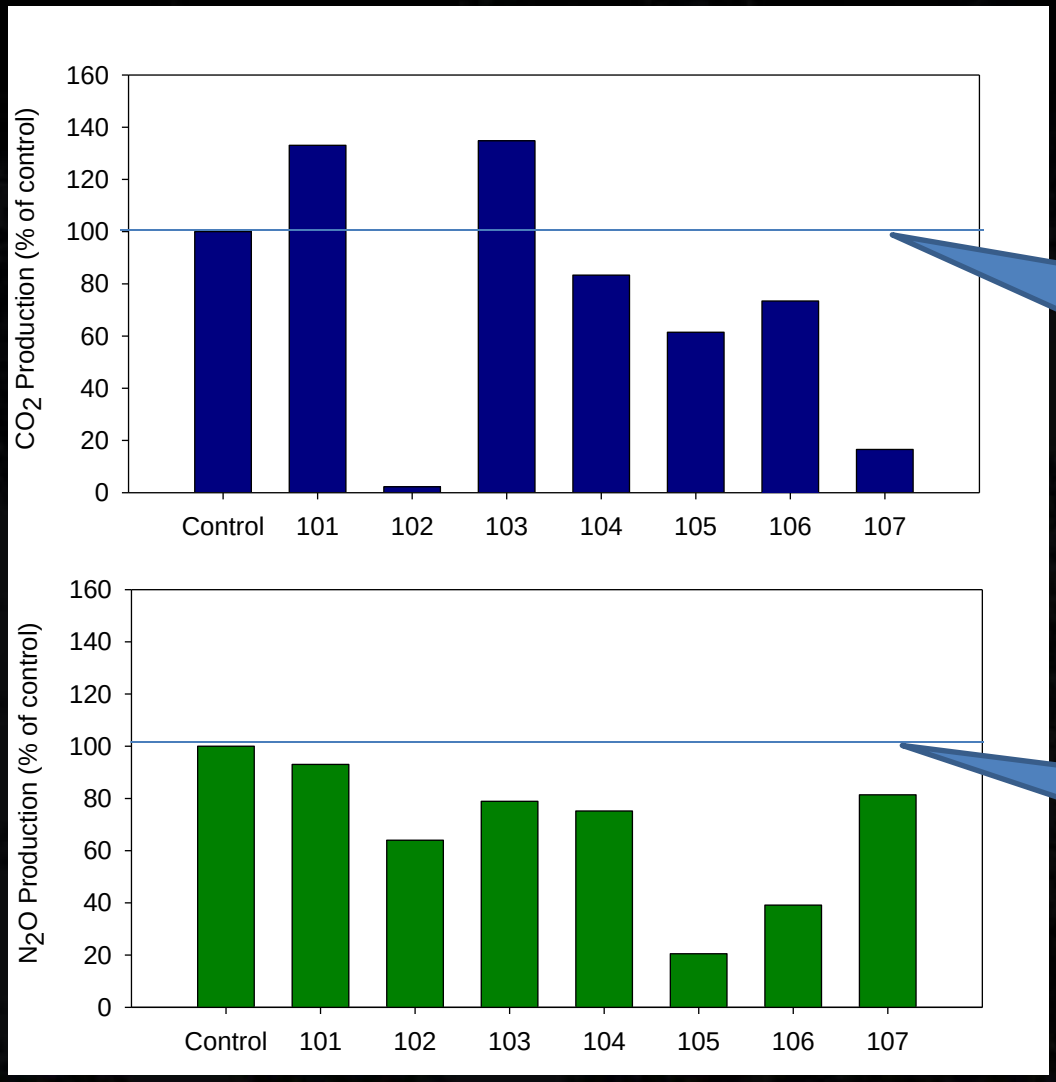


Impacts of Wood Ash on GHG Production/Consumption

- Wood ash samples incubated with Minnesota Ag soil (Waukegan silt loam)
  - 10% w/w addition at field capacity (22 ^{o}C)



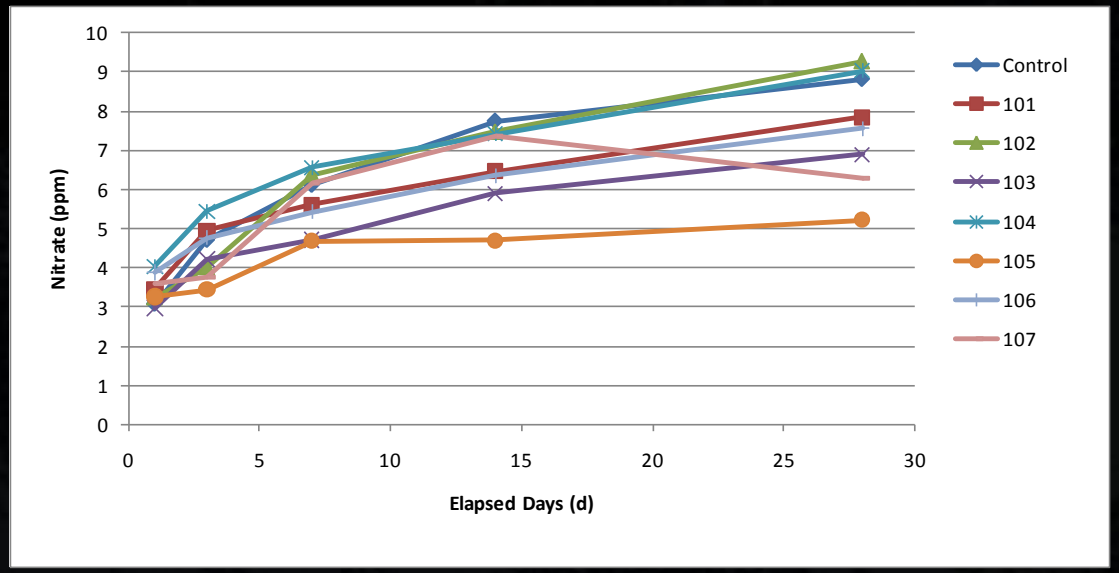
Preliminary GHG Impacts



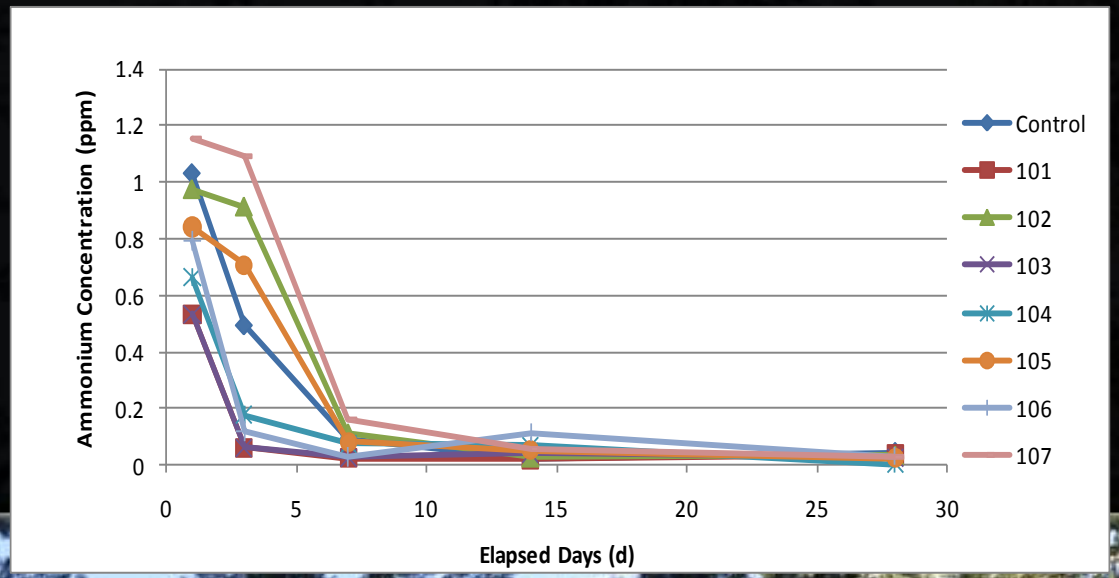
Majority suppressed CO_2 production – slowing over all SOM mineralization?

All wood ashes suppressed N_2O production

Impacts on N-mineralization



5 wood ash lower than control

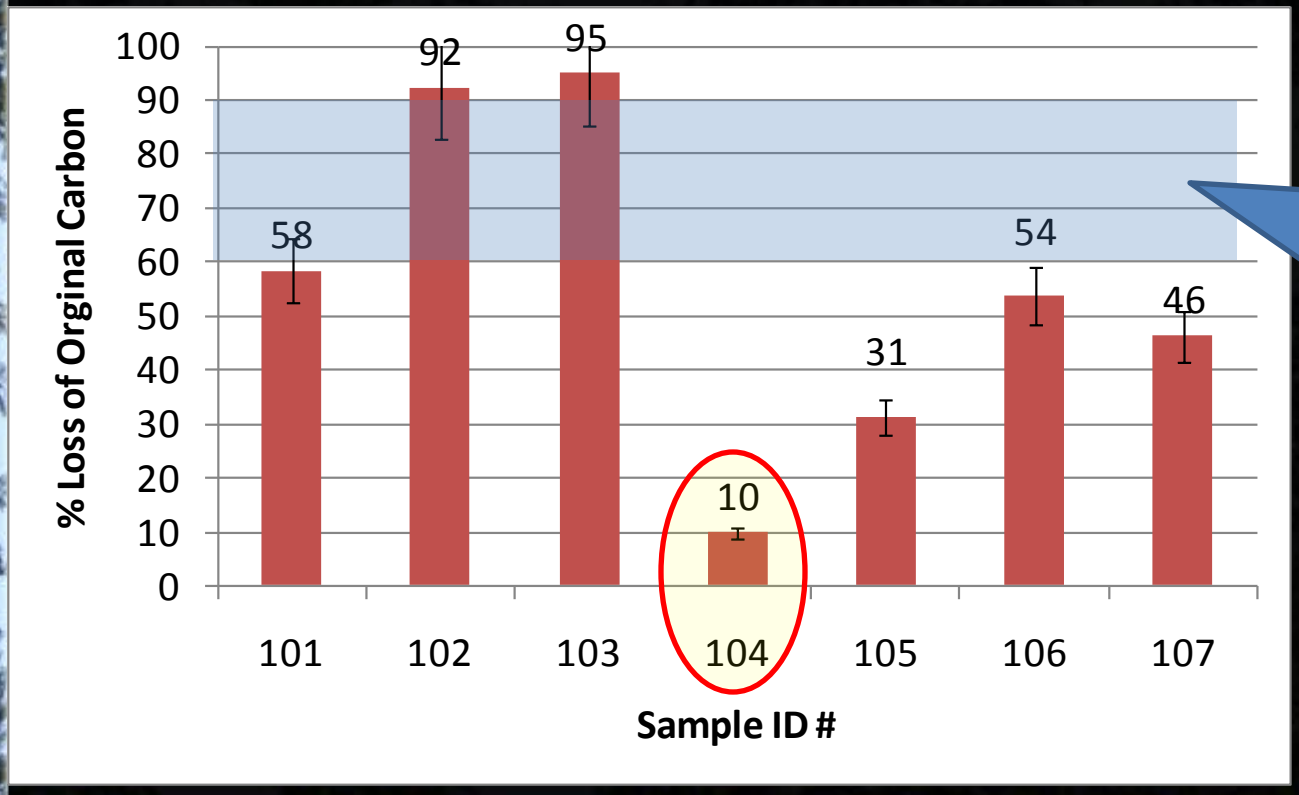


No accumulation of ammonium -- different than biochars

Stability of Carbon

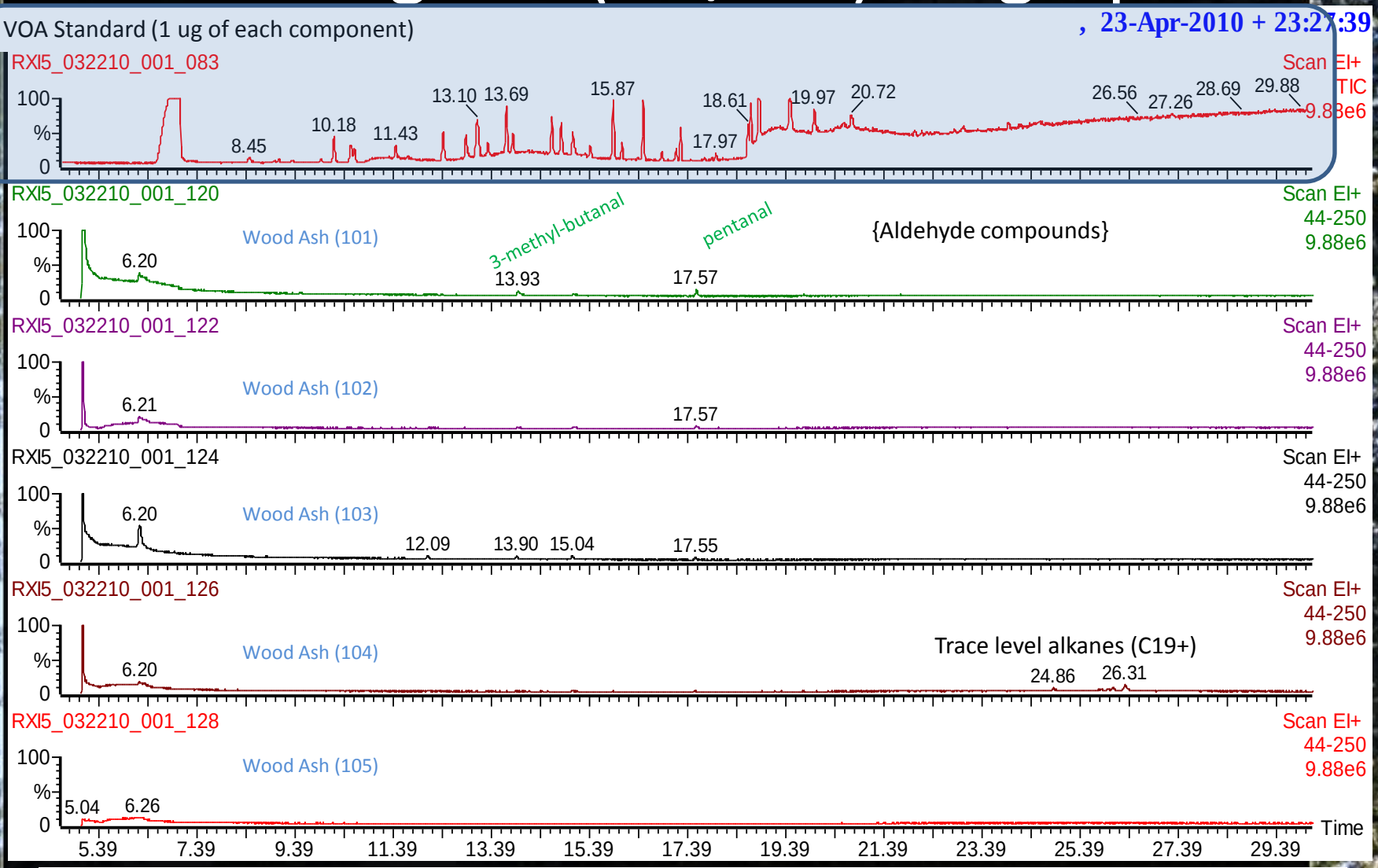
Assessed through CTO-375 (375°C for 16-18 hours)

Chemical Thermal Oxidation test for the quantification of black carbon (recalcitrant carbon : soots, graphite, etc) in sediments (Elmquist et al., 2007)

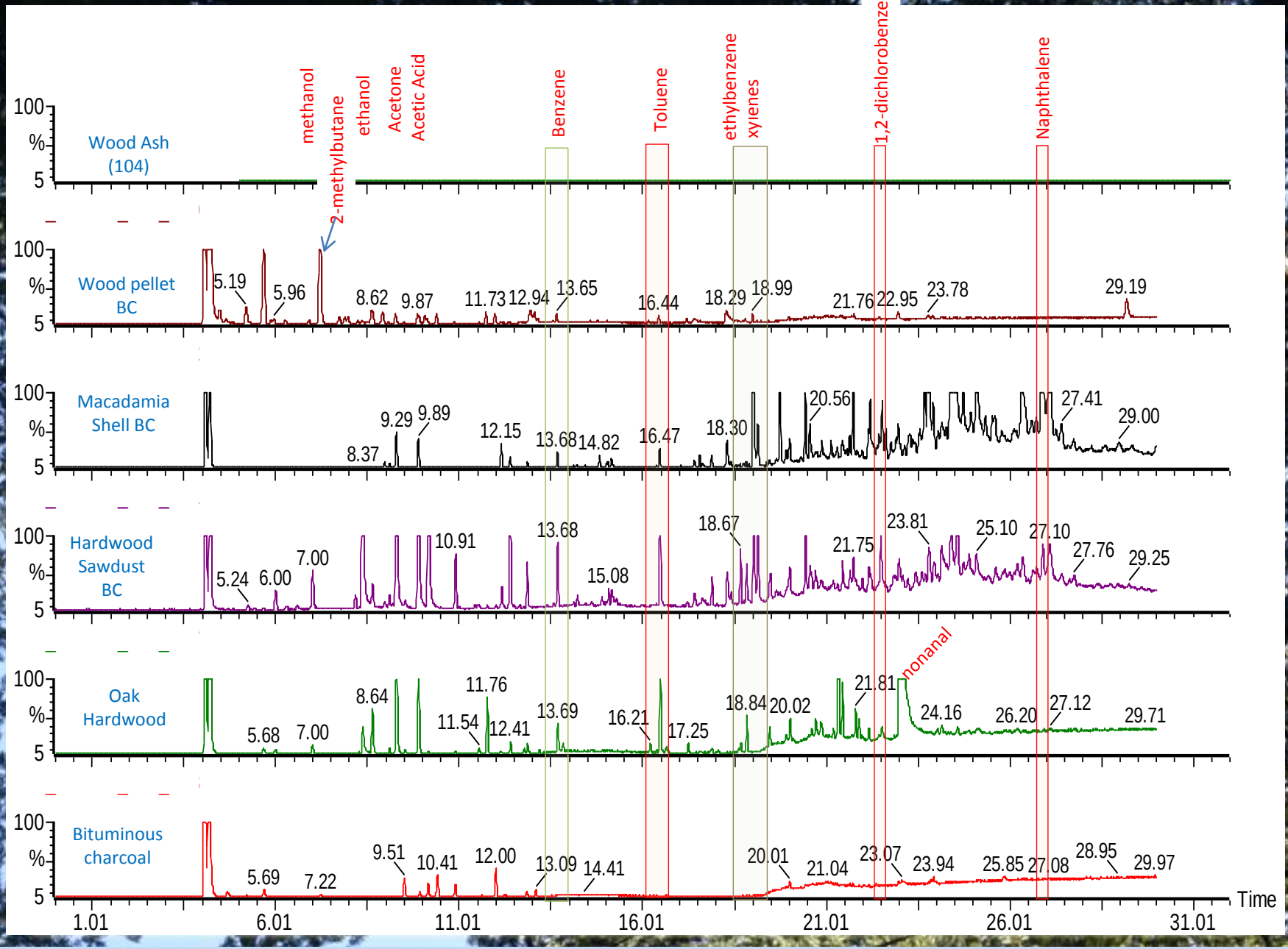


Untreated biochars are typically between 60-90% of carbon lost during CTO-375 test

Volatile Organic (GC/MS) Fingerprints



Very low amount of volatiles observed on wood ash agrees with results of Someshwar (1996).



Biochar typically has higher sorbed volatiles -> potential microbial inhibitors

Preliminary Conclusions

- Overall, wood ash does present an interesting potential for carbon sequestration
  - Converting biomass into recalcitrant carbon, while producing energy at mills
  - What adjustments can be made at individual mills to increase C content?
- Impacts on soil system
  - Similar to biochar, with some differences:
    - Wood ash is cleaner from a sorbed volatile organic standpoint (lower VOC contamination)
    - Concern of pH (pre-treatment?)
    - Lack of impact on ammonia oxidation
      - Still decrease in N_2O production (pH related?)
- Wood ash is typically *lower* in total carbon than biochars, but indications are the C is of higher stability
  - More resistant to oxidation
- Not all biochars (wood ashes) are created equal

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