Observed ethylene production from biochar additions

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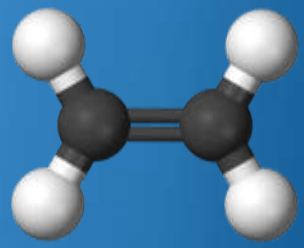
Overview Biochar Impacts

- Various impacts from biochar have been noted in numerous studies
- Both positive and negative:
  - Plant growth effects
  - Plant root impacts
  - Nutrient availability
  - Yield impacts
  - GHG impacts – particularly N_2O
  - Nitrification reduction

Biochar Mechanisms

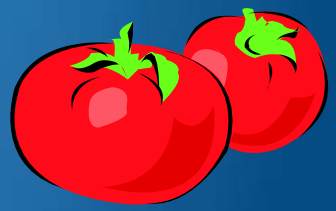
- Alteration of soil physical-chemical properties
  - pH, CEC, decreased bulk density, increased water holding capacity
- Indirect effects on mycorrhizae through effects on other soil microbes
  - Mycorrhization helper bacteria → furan/flavoids beneficial to germination of fungal spores
- Biochar provides improved microbial habitat
- Sorption/desorption of soil GHG and nutrients

Ethylene (Ethene)



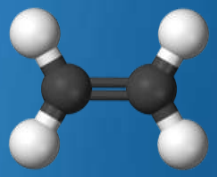
- Long History
  - Ancient Egyptians: Fig ripening
  - Chinese: Pear ripening

  - 1800's gas leaks around street lights : vegetation response
    - 1901 response linked to ethylene
  - Activated charcoal added to shipping containers to sorb ethylene and reduce fruit ripening
  - Ethylene used to stimulate ripening
    - Bananas, tomatoes



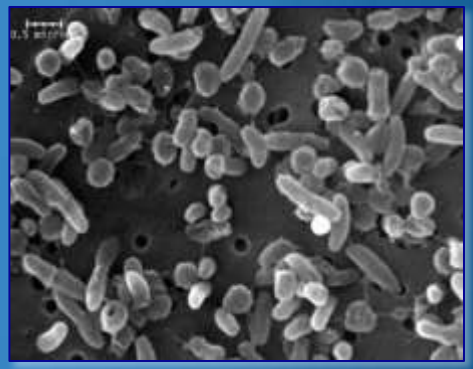
- Largest human produced organic compound

Ethylene Plant Effects

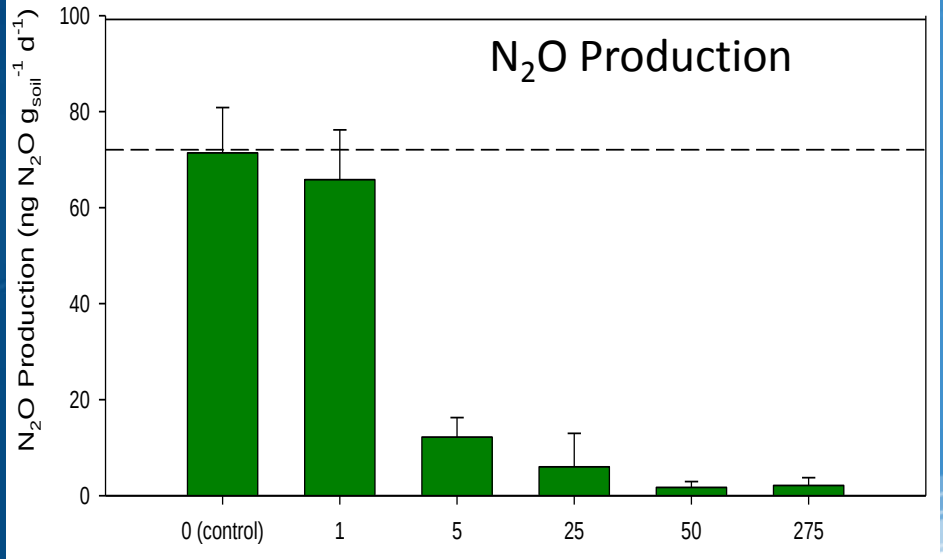


- Plant hormone - Numerous studies and very active:
  - Increases fine root development
  - Induces seed germination (dormancy release)
  - Stimulates leaf and flower senescence
  - Inhibits shoot growth in some plant species and in others causes stem elongation
  - Increasing the efficiency of root uptake of water and minerals
  - Stimulates fruit ripening & flowering in some plants
  - Prevents stomata closing in some plants
  - Produced during plant damage & disease
- Pleiotropic effects
  - Not essentially a direct linkage
    - Also a function of the environment

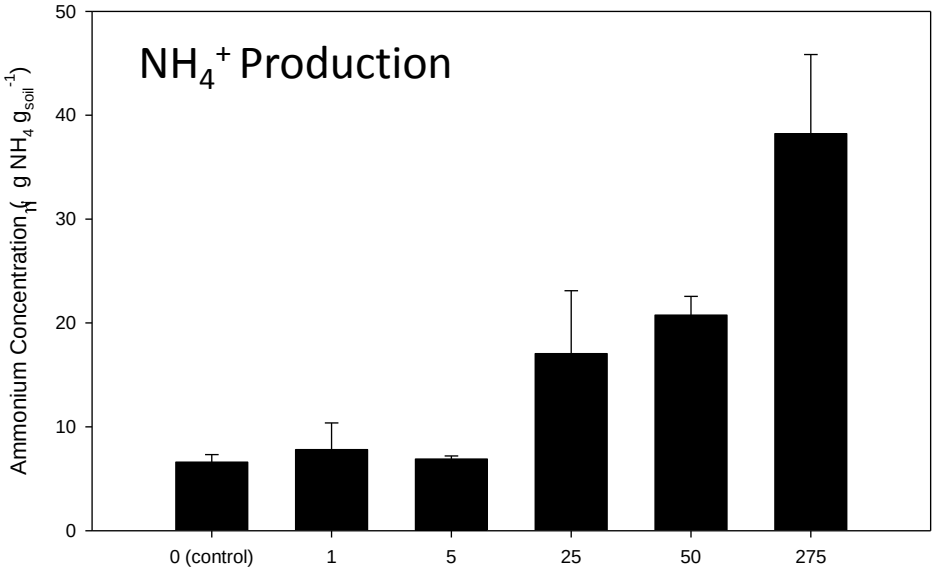
Ethylene Impacts



- Soil Microbial Impacts
  - Induces fungal spore germination
  - Inhibits/reduces rates of nitrification/denitrification
  - Inhibits CH_4 oxidation (methanotrophs)
  - Involved in the flooded soil feedback
    - Both microbial and plant (adventitious root growth)



Ethylene Headspace Concentration (0 to 275 ppmv)



Ethylene Headspace Concentration (0 to 275 ppmv)

Biochars Examined

	Biomass	Pyrolysis Temp/type	Surface Area	% C	%O	%N	%VM	%Ash	%Fixed C
Activated Charcoal	Coconut shell	450	977	83	<0.1	0.4	2	15	83
BC-1	Hardwood sawdust	500 *fast*	10	67	13	0.3	29	15	55
BC-2	Macadamia nut	600 *flash*	7	93	2	0.7	17	2	81
BC-3	Hardwood chip	550 *slow*	66	71	21	0.1	35	5	61
BC-4	Distillers grain	350 *slow*	0.3	69	7	7.5	45	11	43
BC-5	Distillers grain	400 *slow*	0.3	69	6	7.4	38	12	50
BC-6	Corn cob	350 *slow*	<0.1	79	13	0.7	33	3	64
BC-7	Corn cob	400 *slow*	<0.1	83	9	0.6	25	4	71
BC-8	Mixed wood	400 *slow*	4	80	12	0.8	27	4	70
BC-9	Mixed wood	450 *slow*	27	81	11	0.8	24	4	73
BC-10	Wood pellets	400-500 *slow*	2	73	19	0.2	12	6	81
BC-11	Wood waste	400-500 (updraft gasifier)	34	32	<0.1	0.3	20	67	13
BC-12	Peanut shell	481 *slow*	1	59	3	12	40	15	45

Biochars Examined Summary

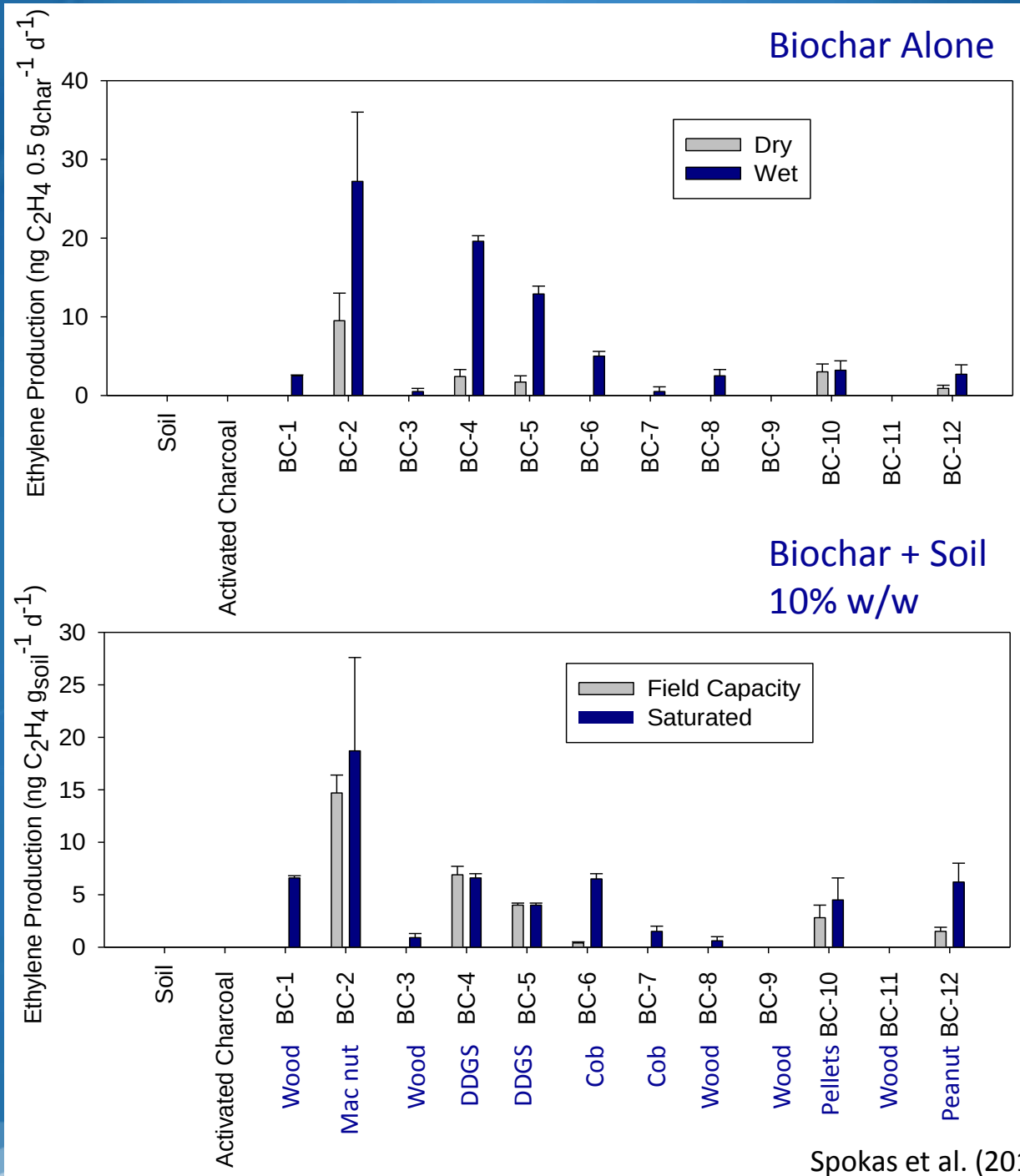
- Variety of Biochars
  - Variety of production conditions
  - Parent biomass types: 7 presented here
  - Range of C contents: 32-93%
  - Range of O contents: 0 to 21%
  - Range of N contents: 0.1 to 12%
  - Range of VM contents: 2 to 45%
  - Range of Ash contents: 2 to 67%
  - Range of Fixed C: 13 to 83%

Laboratory Biochar Incubations

- Soil incubations:
  - Serum bottle (soil + biochar)
    - 5 g soil mixed with 0.5 g biochar (10% w/w) [GHG production]
      - Field capacity and saturated
      - Oxygen & soil sterilization effects

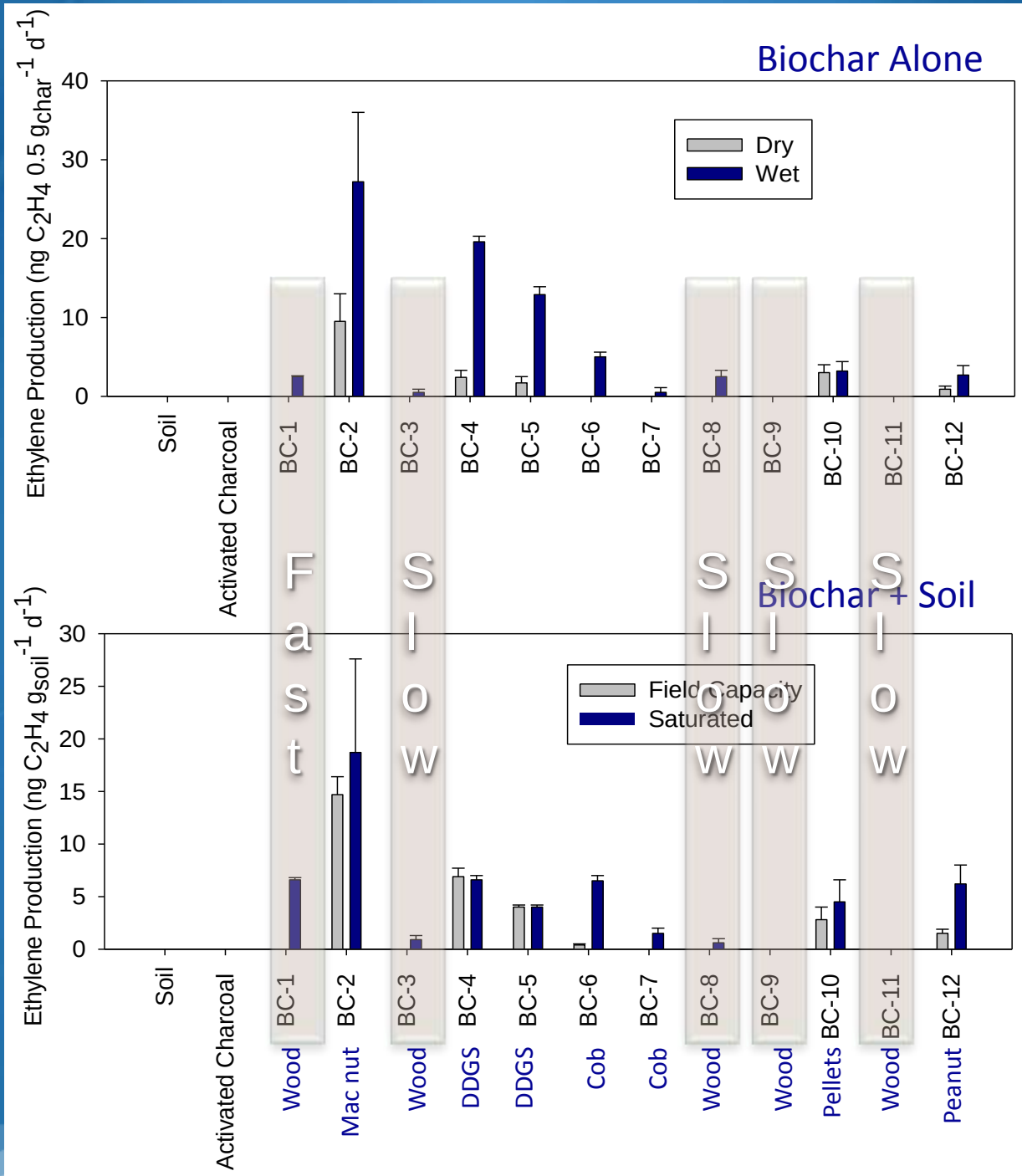
  - Mason Jar (soil + biochar/isolated)
    - Looking at impact of biochar without mixing with soil

Ethylene Production Rates

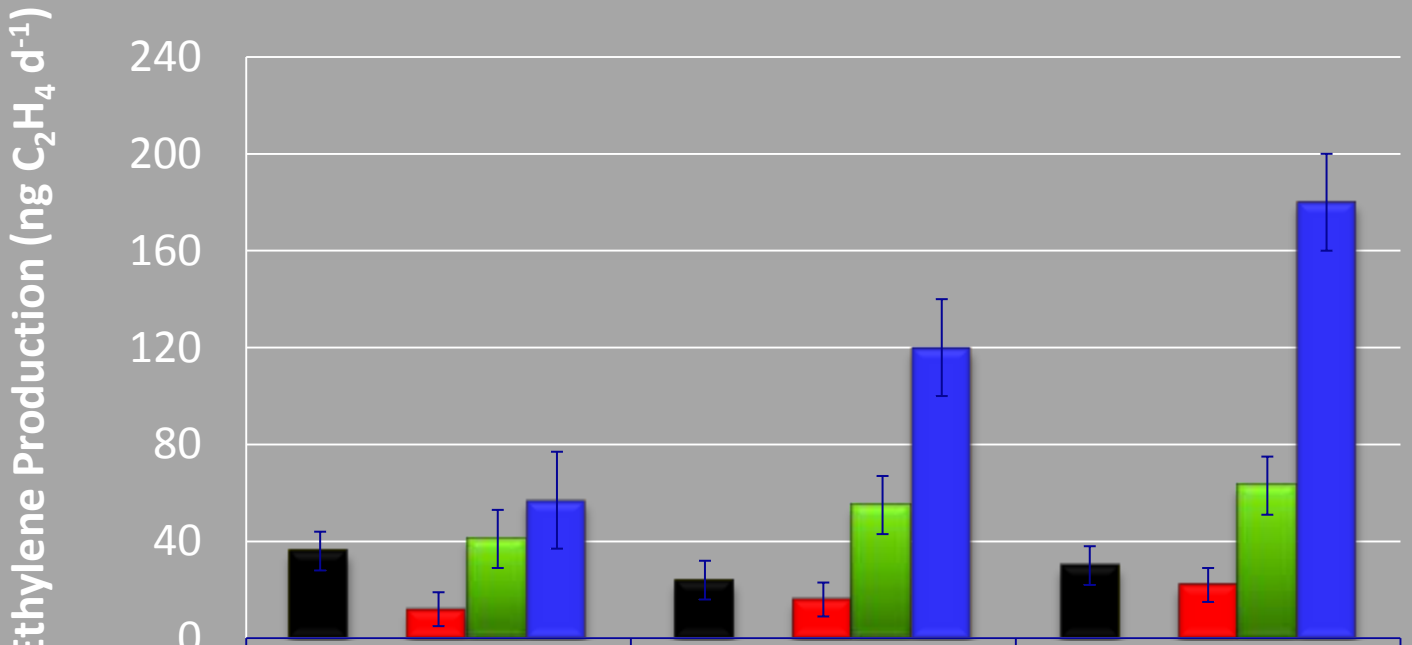


Spokas et al. (2010)

Ethylene Production Rates



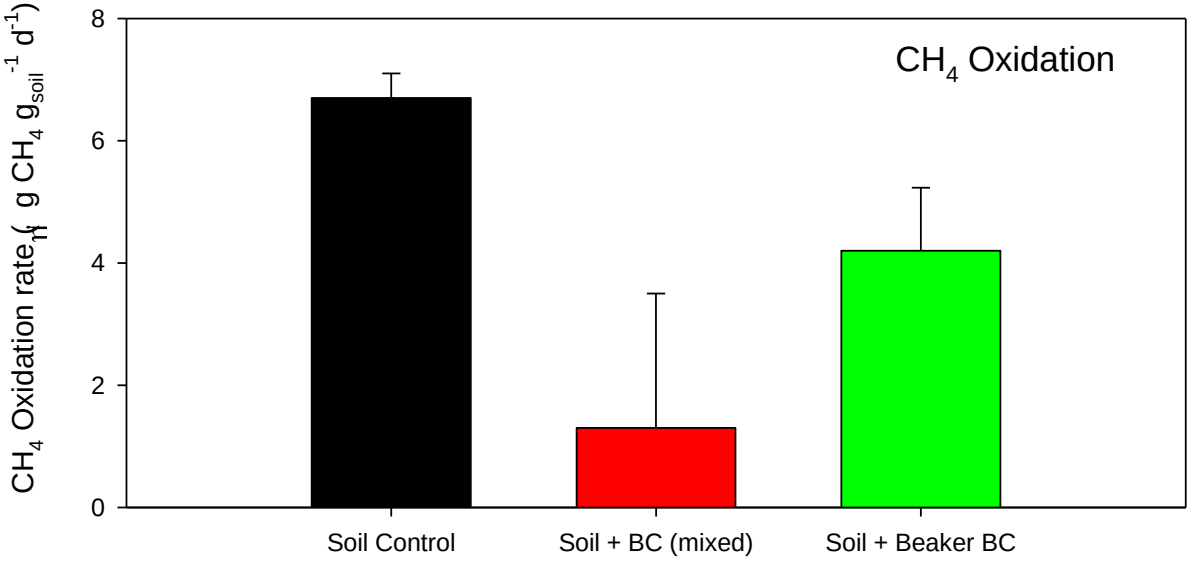
Oxygen and Soil Sterilization Impacts

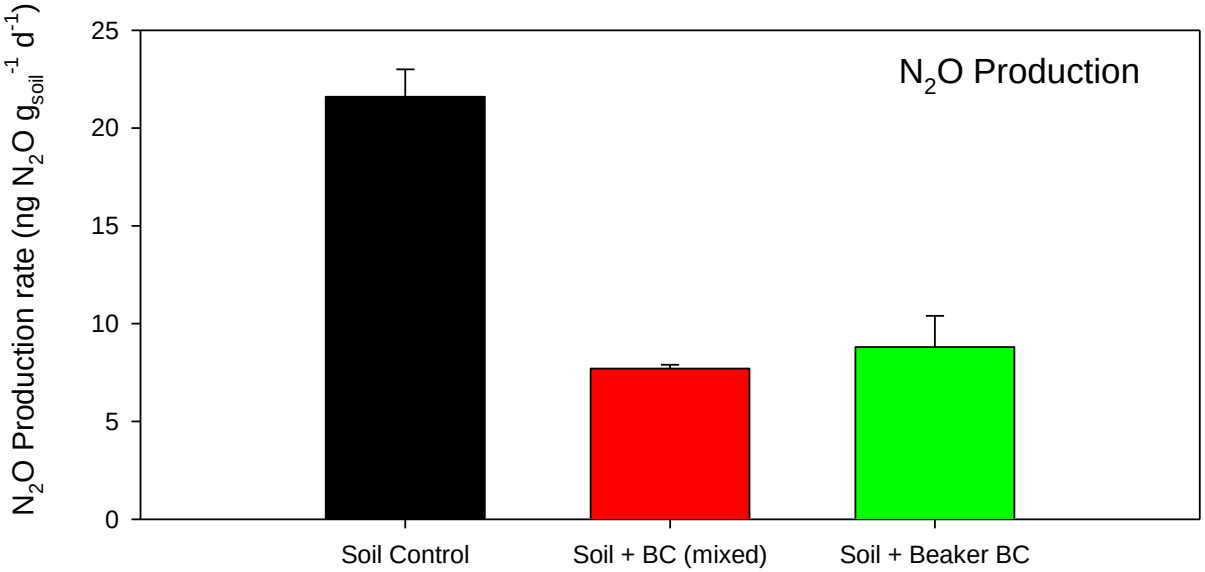


	0% Oxygen	20% Oxygen	40% Oxygen
Biochar Alone	36	24	30
Non-Sterile Soil	0	0	0
Sterile Soil	12	16	22
Biochar+ Sterilized Soil	41	55	63
Biochar+Non-sterilized Soil	57	120	180

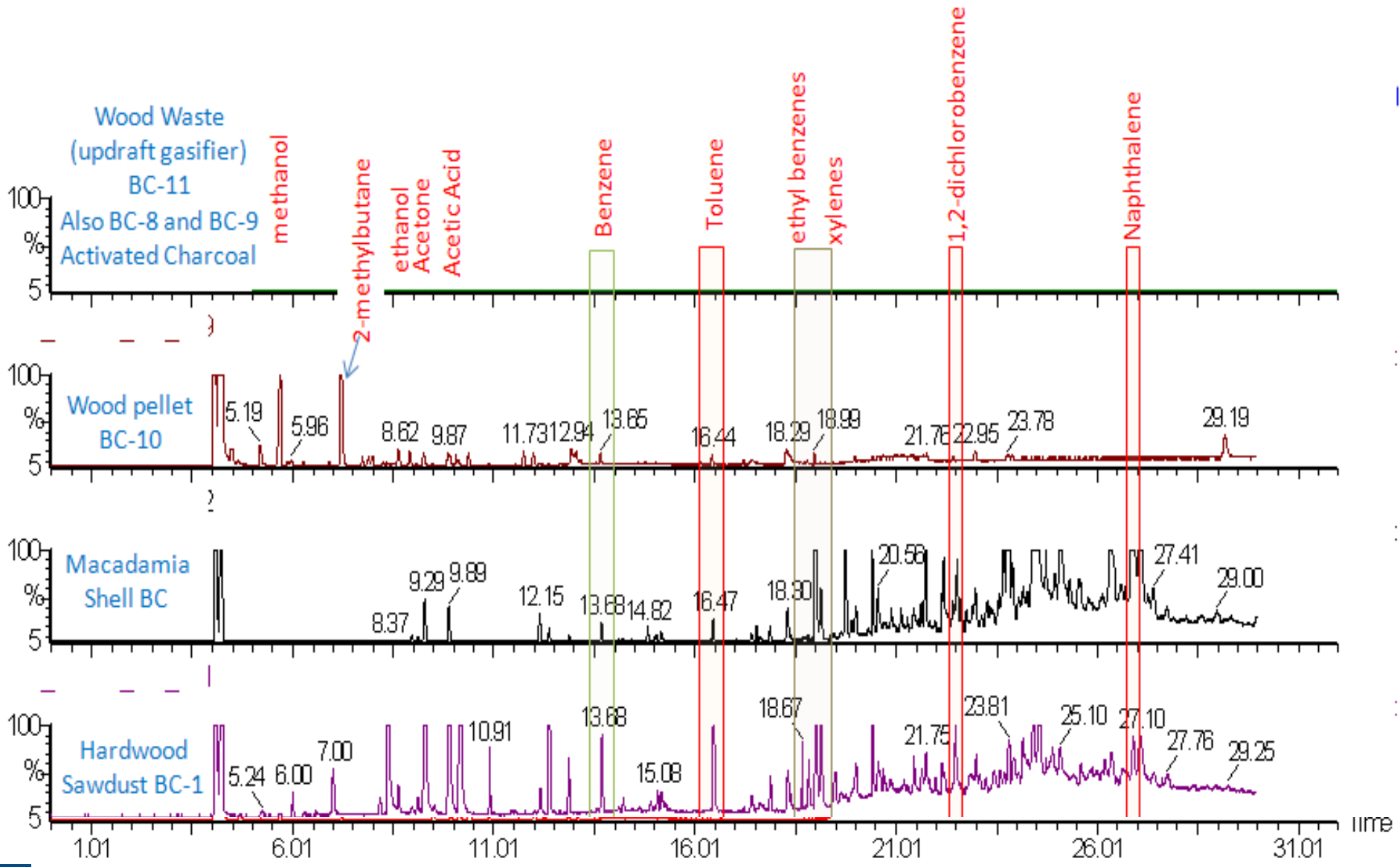
Macadamia nut biochar presented above

Biochar isolated or mixed with soil





In addition to Ethylene- Sorbed VOC's



Headspace thermal desorption of biochars analyzed by GC/MS

Conclusions

- Another piece to the puzzle: Ethylene + VOC's
  - Sorbed volatiles and degradation products (ethylene) should be included in the potential biochar mechanisms
  - Microbial inhibitors/plant effects
- Highly variable and different responses to biochar as a function of soil ecosystem (microbial linkage)
  - Agricultural, forest, prairie, urban
  - Age of biochar (from production) also enters into the factors
- Directly impacts degradation/mineralization rates of biochar due to impact on microbial rates

Conclusions (continued)

- Biochars with lower sorbed volatiles
  - In general, lower production of ethylene (not always)
- Ethylene production has both abiotic & biotic components
- All biochars do not produce ethylene
- Ethylene production lower at higher production temperatures – still requires further investigation

"The Nation that destroys its soil destroys itself"

Franklin D. Roosevelt

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