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Co-Composting with Biochar: Research, farmer, and industry perspectives

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Note about on-line version of these slides: Results of unpublished research have been removed.

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Opportunities for composters to use biochar in the composting process

1. Biochar as a feedstock
2. Biochar as a compost blanket or biofilter
3. Biochar – Compost mix (post composting)

Focus is on odor reduction, nitrogen retention, and producing a carbon-rich, stable product that will enhance plant growth and store carbon.

Sobol and Dyjakon, 2022
Revista de Chimie, 3 (4), 2022, 86-96

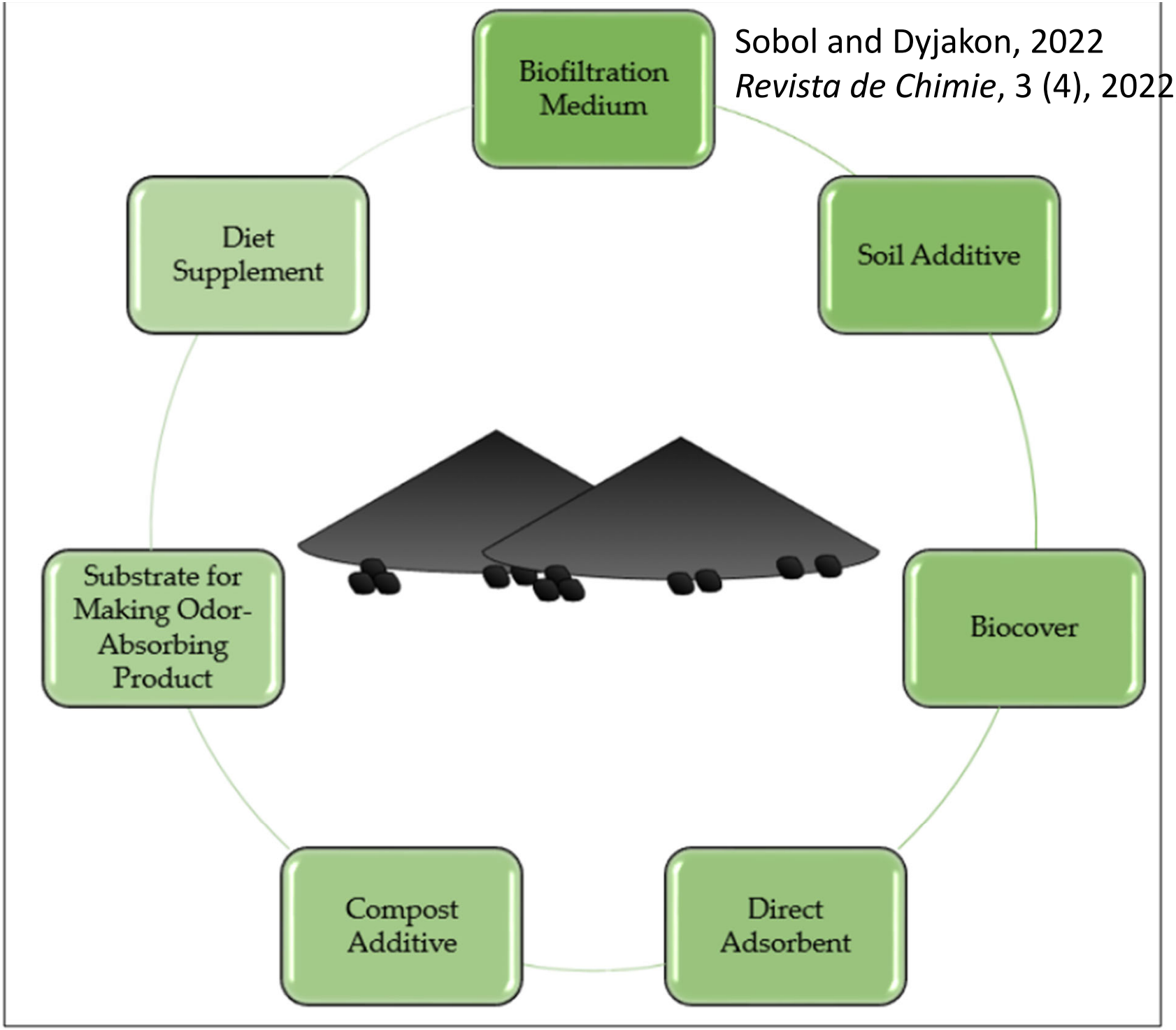

Figure 1. Biochar use in odor removal systems

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Odor issues in compost

- Ammonia
- Sulfur compounds

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Nitrogen loss in compost

- Ammonia accounts for ~98% of N loss
  - NH_3 can account for 24-33% of total initial N

Organic N

NH_4+

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Nitrogen loss in compost

ammonia

NH_3

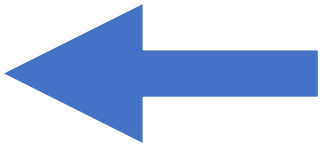
Volatile gas

ammonium

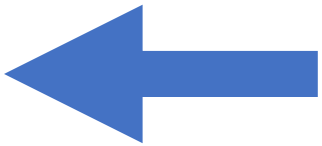
NH_4+

Cationic solid

Increasing pH
(H+ stripped off)



Increasing temperature
Reduced NH_4+ solubility



NH_3 is mainly lost during the thermophilic stage,
And through forced aeration and turning

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Biochar as a feedstock

1. Reduced N loss, especially NH_3

- Increase aeration
- Reduce odor, especially H_2S (Hydrogen sulfide) and other sulfur compounds

- This opportunity comes from both an increase in surface area and the ability to **influence surface charge**.

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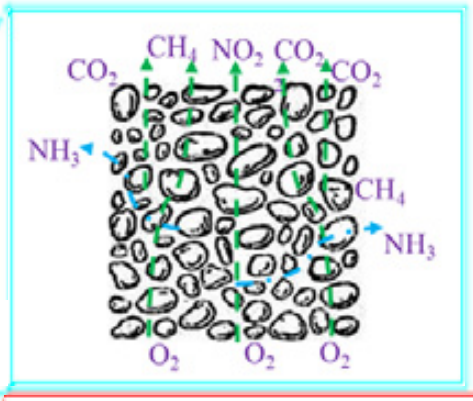
Co-composting involves using biochar as a feedstock

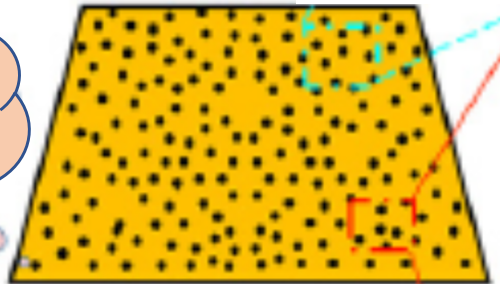
Traditional composting

Higher NH_3 and GHG

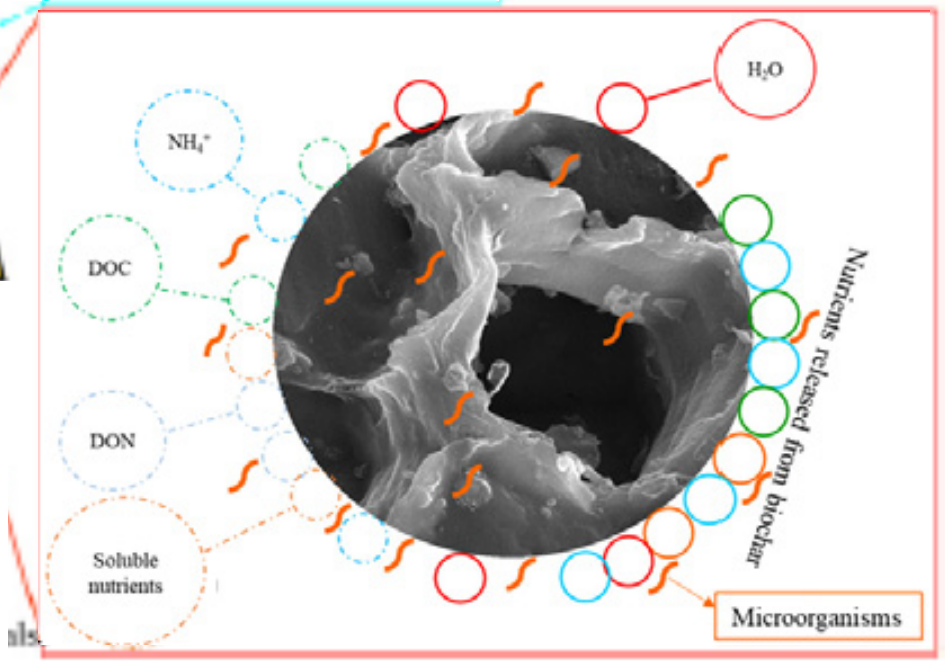


biochar

Higher compost peak temp. Higher CO2



Biochar- amended windrow compost profile



Enhanced pile structure and aeration
Promoted OM degradation and maturity
Decreased N loss
Reduced NH3 and GHG emissions
Heavy metal stabilization

Xiao et al, 2017. Bioresource Technology..

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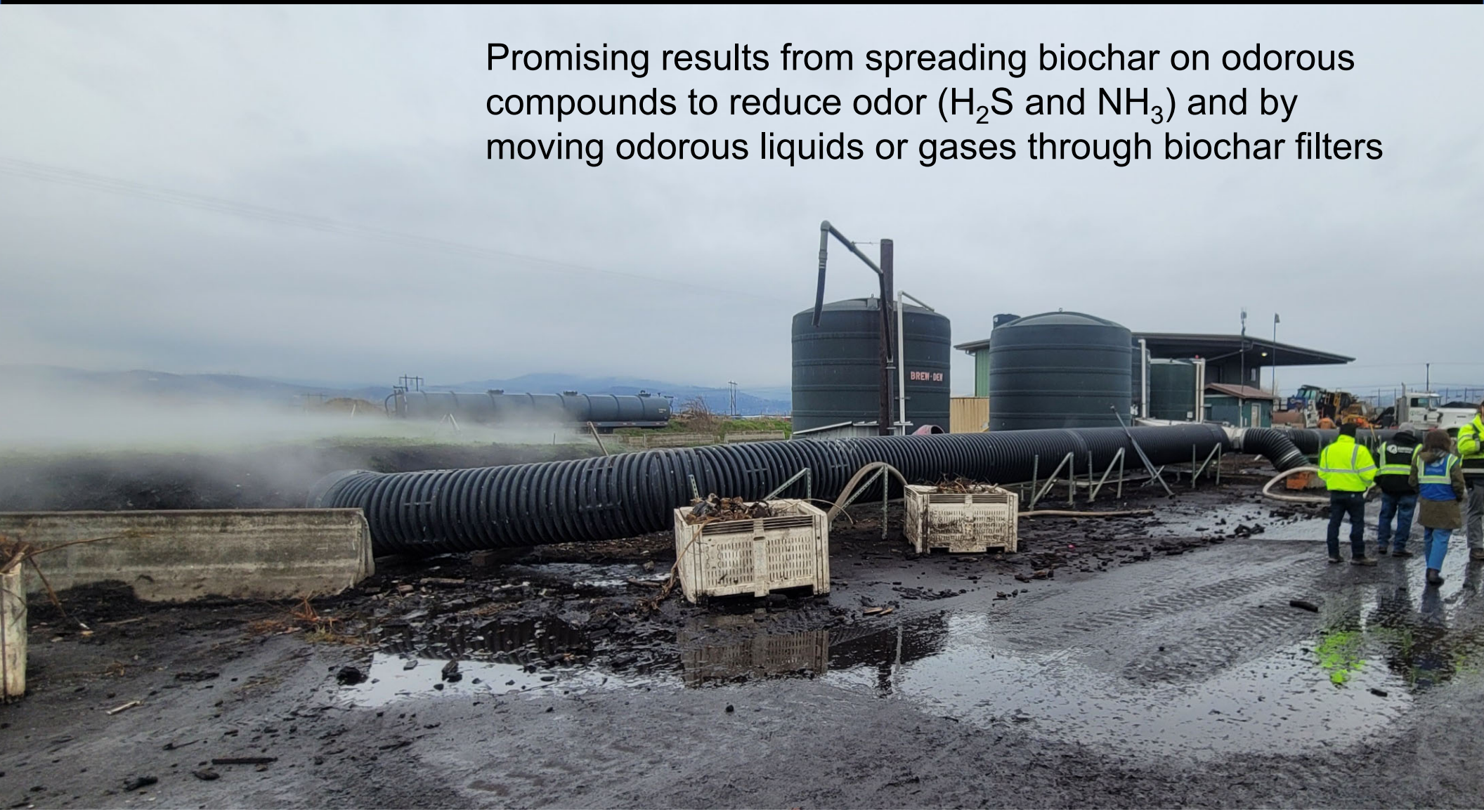
Biochar provides opportunities for compost blankets and biofilters

Promising results from spreading biochar on odorous compounds to reduce odor (H_2S and NH_3) and by moving odorous liquids or gases through biochar filters



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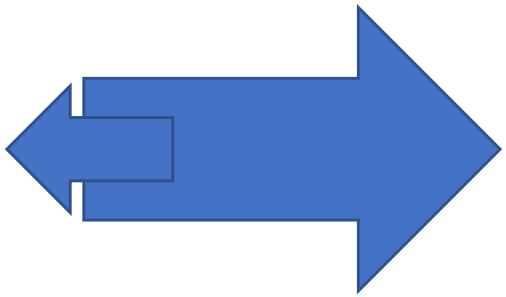
Biochar provides opportunities for influencing compost curing and/or pre-sale mixes

Compost with high nutrient  **Biochar with low nutrient**

"The higher the initial content of an element in an incubated-compost medium, the higher the chance that it would translocate to an incorporated biochar."

Khan et al. / Chemosphere 142 (2016) 14–23

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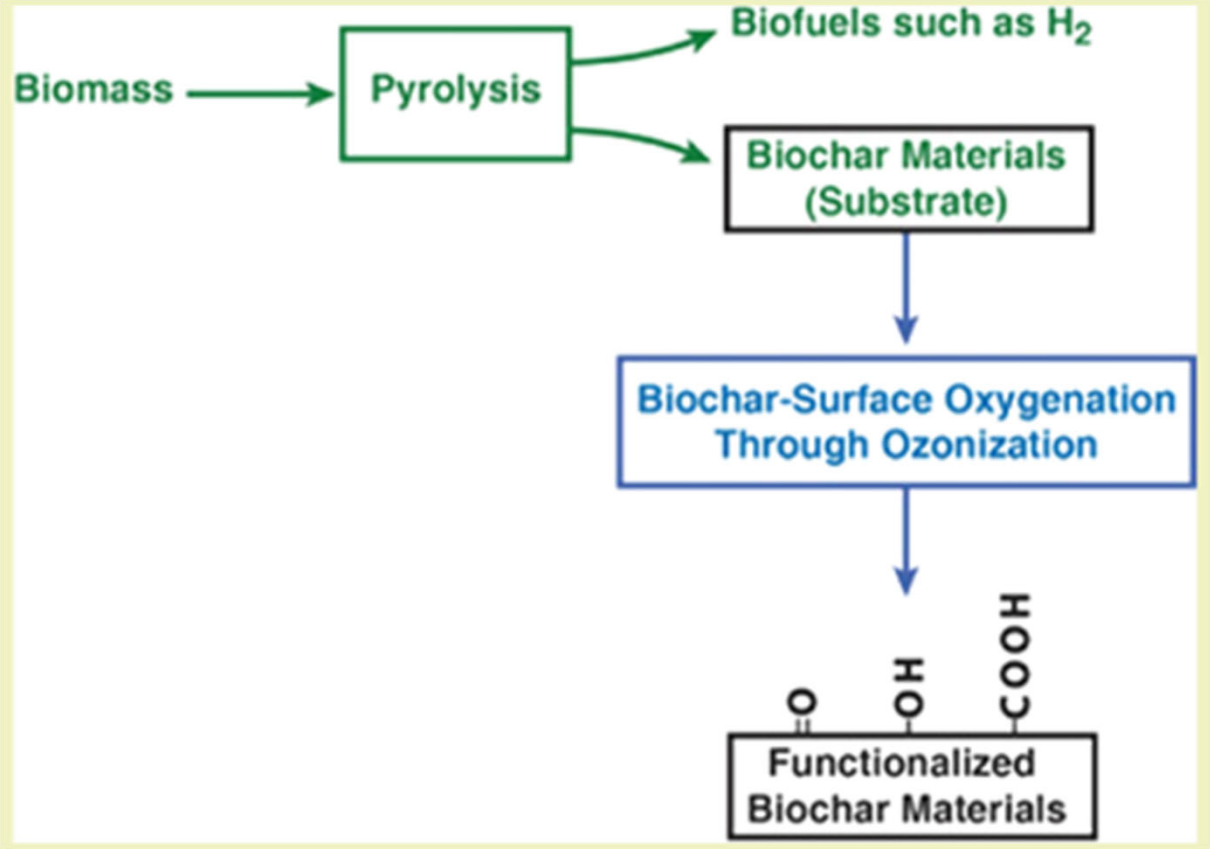
Chemical or Physical activation?



Kharel et al. 2019. Biochar Surface Oxygenation by Ozonization for Super High Cation Exchange Capacity. ACS Sustainable Chem. Eng. 2019, 7, 16410−16418

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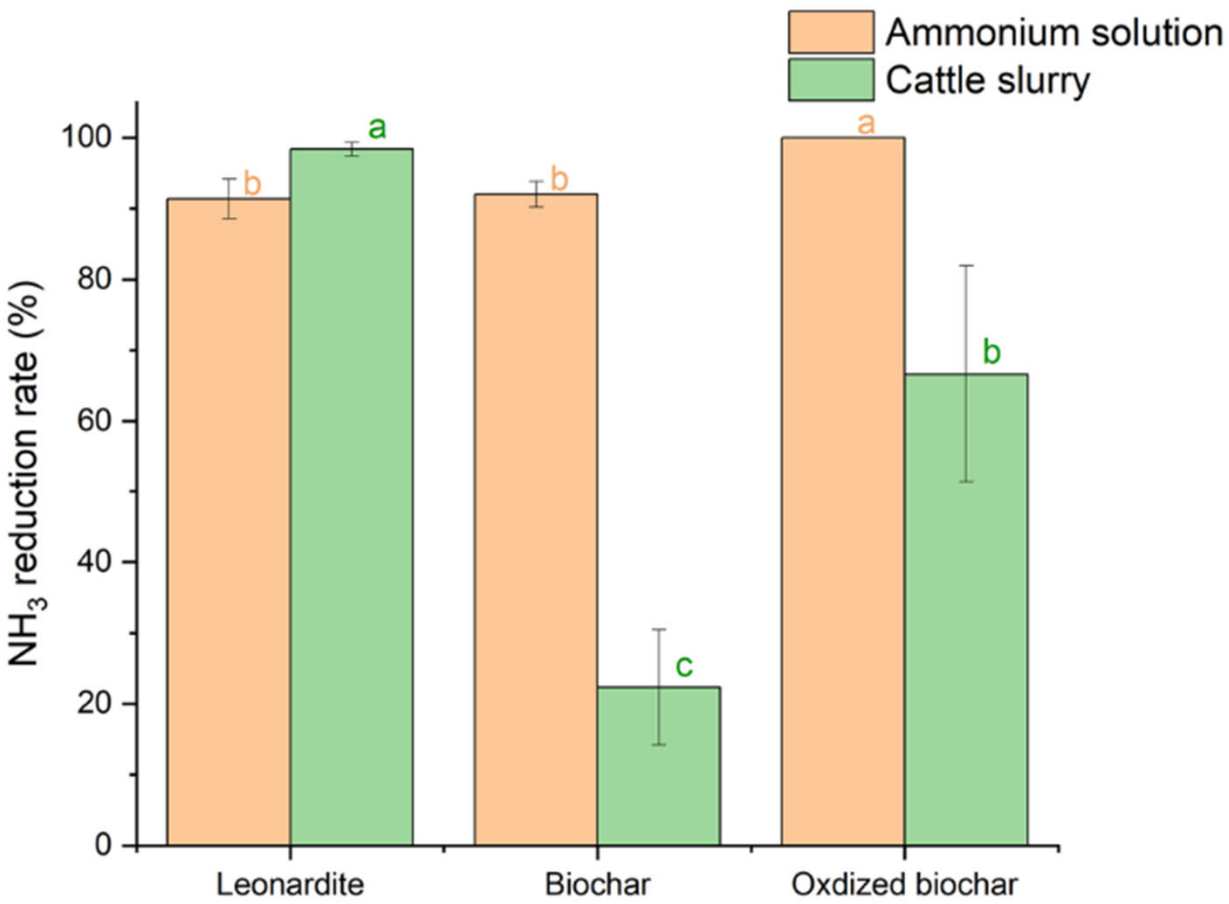
Chemical or Physical activation?



- Cao et al, 2022. Fenton oxidation of biochar improves retention of cattle slurry nitrogen. J. Environ. Qual. 2022;51:1319–1326.

- Fenton reaction produces highly reactive HO- radical, a powerful oxidizing agent (i.e. coating the surface with oxygen)

Biochar feedstock, temperature, and age affect properties

Parameter	Low Temp (~350 C)	High Temp (600-900 C)
Porosity	Lower	Higher
Surface Area	Lower	Higher
Cation Exchange Cap	Lower	Higher
Oxygen Content	Higher	Lower
Acid-Base Fnxl groups	Higher	Lower
Nutrient Availability	Higher	Lower
Parameter	**Young Char**	**Aged Char**
Negative functional groups (charge)	Fewer	More
Oxidation	Less	More

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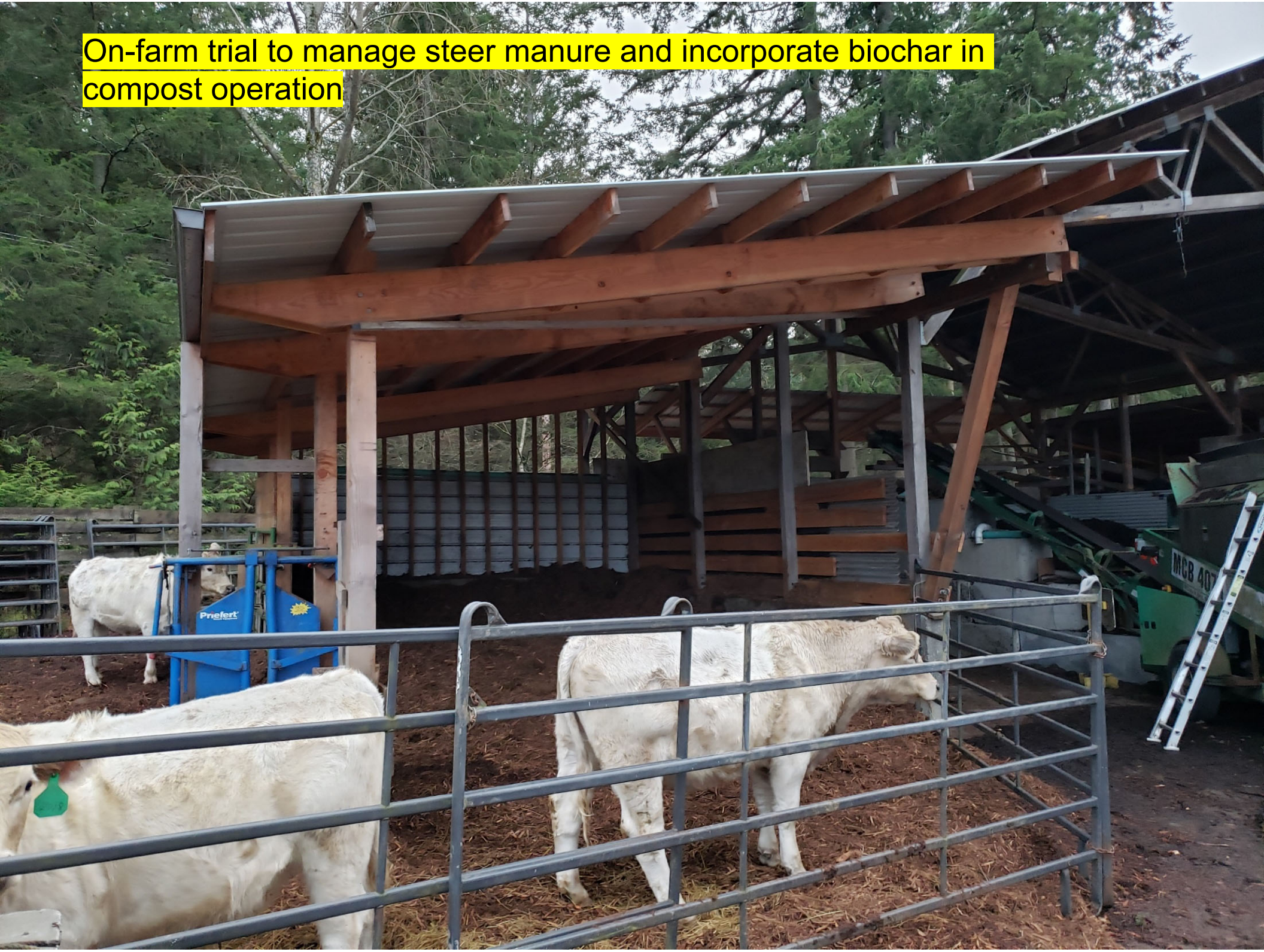
Composting and incubation is good for biochar application

Research trials with compost and biochar

1. Biochar incubation in high use animal overwintering prior to composting
2. Meso scale (2 cu yd) co-composting to assess nitrogen dynamics and pile temperature
   a) Does biochar at 20% and 40% reduce N loss during composting?


On-farm trial to manage steer manure and incorporate biochar in compost operation
Priefert

Biochar buried bag

Photo courtesy: Henry Sintim, SARE project: Biodegradable plastic mulches: performance, degradation, and impacts on agroecosystems

1

Three treatments:

- Wood chips (>=12.5mm)
- Olympic biochar (0.5-8 mm, 90%, 1000 C)
- Oregon biochar (1-4 mm, 96%, 871 C)

8.8 g dry wt.

Mesh bags

10 x 12 cm

250 µm

Co-Composting Trial Feedstocks and experimental design

Feedstock	% C	%N	C:N	% Moisture	Bulk Density (lb/cu yd
Chicken Manure	27.8	2.2	13	45.2	28.1
Wood Shavings	51.0	0.2	255	65.3	34.6
Biochar	86.0	0.8	27	61.9	45.3

Wood shavings

Chicken manure

Biochar

26% of N was ammonium

Co-Composting Trial :

Pre-trial to determine free air space in different wood shaving : chicken manure ratios. Target C:N=25.:1; Target Free air space = 35-60%

Mix (WC:Manure)	C:N	Free Air Space %
3:1	22	28.1
4:1	25	34.6
5:1	27	45.3

- Compost feedstocks: wood shavings:chicken manure at 4:1 ratio(v/v) and biochar at 0%, 20%, or 40% (v/v).

Wood shavings

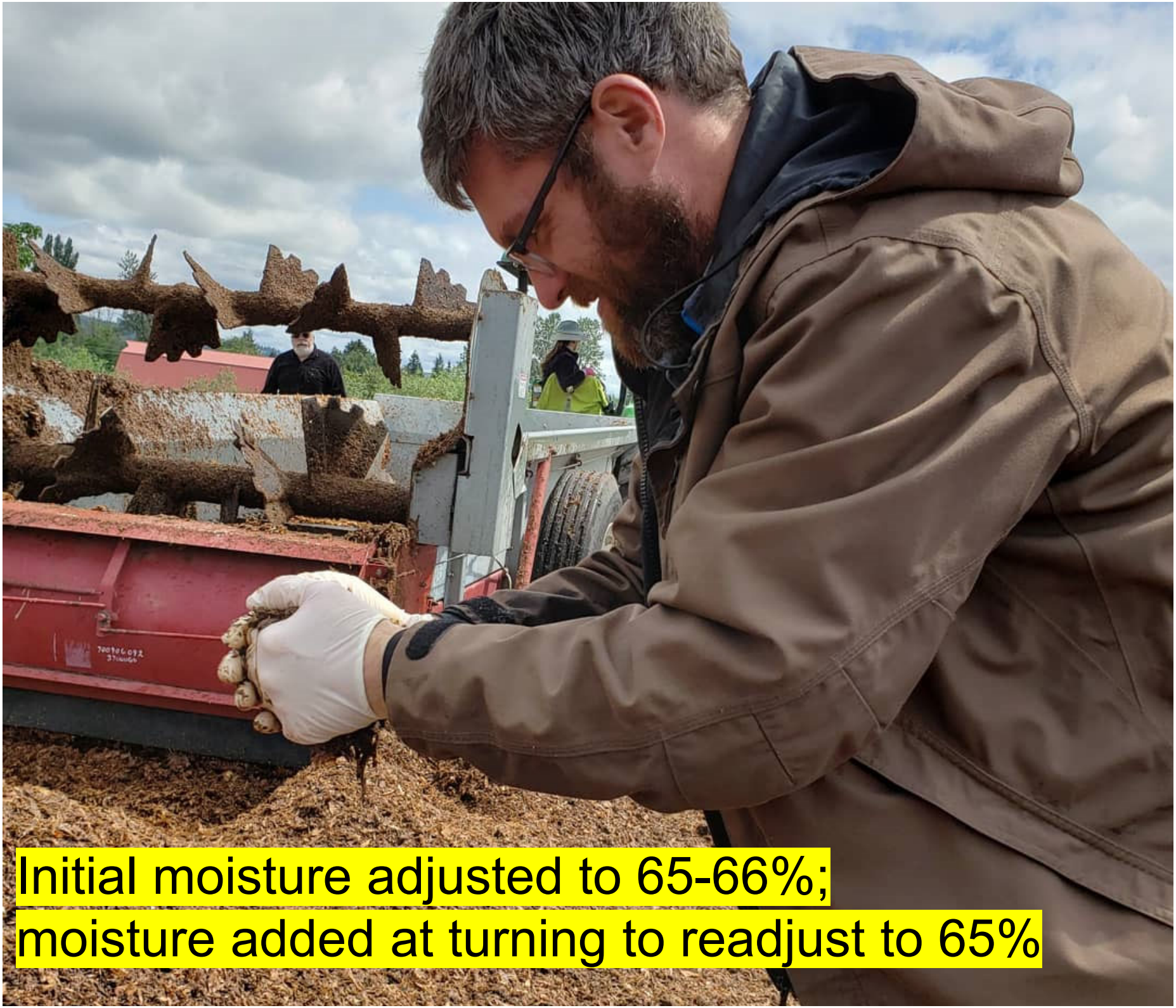
Chicken manure

Biochar

Aerated 2 cu yd composting vessel

1300 – 1560 lbs starting weight

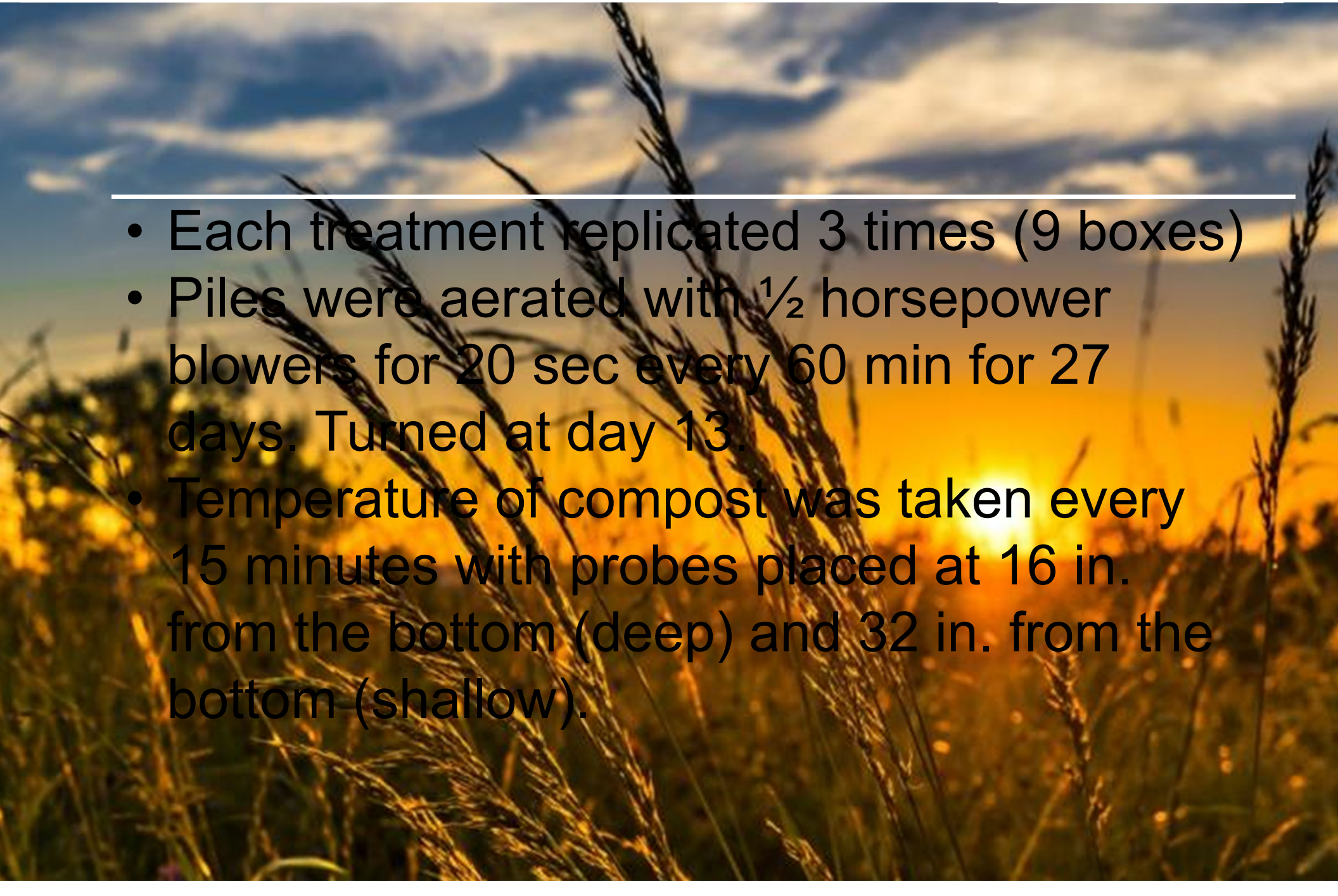

NEW IDEA


Initial moisture adjusted to 65-66%;
moisture added at turning to readjust to 65%

Plenum layer:
41.6 lbs

Truck scales used for monitoring initial pile mass and losses.


5gallons



- Each treatment replicated 3 times (9 boxes)
- Piles were aerated with ½ horsepower blowers for 20 sec every 60 min for 27 days. Turned at day 13.
- Temperature of compost was taken every 15 minutes with probes placed at 16 in. from the bottom (deep) and 32 in. from the bottom (shallow).

Nutrient Analysis

Biological Assay & Respirometry

Other Physicochemical Properties

Date (in 2019)	Event
May 21st , 22nd, & 23rd	Compost piles built
June 3rd, 4th, & 5th (Day 13)	First turn & moisture adjustment
June 24th & 25th (Day 33-34)	Second turn & sample collection for analysis

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Identify goal or problem. Biochar may be part of the solution

1. Increase stable C
2. Decrease odor
3. Reduce N loss

Feedstock

Blanket/Biofilter

Mix and Mellow

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Thank you!

Questions?

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