Compost Analysis Overview

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Randy Freed, ICF International

ICF INTERNATIONAL

Objectives

- Describe methods and data underlying current compost emission factors
- Provide basis for discussing
  - Gaps in analytic framework
  - Inclusion of newer/better data

Compost Emission Factor Breakdown

Net Emissions* = -0.05 MTCE/Ton

Potential GHG Emissions

- **CO_2 from transportation to facility and turning of compost**: 0.01 MTCE/Ton
- **Biogenic CO_2**: 0 MTCE/Ton
- **Compost CH_4**: 0 MTCE/Ton

Potential Carbon Storage

- **Soil carbon sequestration**: -0.02 MTCE/Ton for soil carbon storage + -0.05 MTCE/Ton for increased humus formation

*The totals do not sum due to rounding.

Source: EPA, 2006. *Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks*. Developed by ICF International for EPA. Available at http://epa.gov/climatechange/wycd/waste/SWMGHGreport.html#sections

Potential GHG Emissions

- CO_2 from transportation to facility and turning of compost
  - Estimated from yard trimmings collection, transport, and operation of a windrow compost facility.
  - Energy usage (in thousand Btu per ton of yard trimmings composted) was collected from Franklin Associates estimates from the early 1990s.
  - Converted these energy estimates to CO_2 emissions assuming diesel fuel combustion.

Potential GHG Emissions (cont.)

- Compost CH_4
  - Assumed to be 0 for "well-managed" compost operations, i.e., any CH_4 generated within the pile is assumed to be oxidized and converted to CO_2.
- Biogenic CO_2
  - Not counted as a GHG under IPCC accounting principles for CO_2 from sustainably harvested biogenic sources.

Potential Carbon Storage

Four potential processes

1. Accumulation of applied carbon (soil carbon restoration)
2. Greater standing crop of biomass due to nitrogen fertilization
3. Conversion to slowly degrading humic materials in composting process
4. High rates of compost application changing the equilibrium level of biomass (not analyzed)

1. Soil Carbon Restoration

- Utilizing the CENTURY model:
  - Basic agricultural scenarios for land converted from prairie to corn-growing farmland simulated to grow from 1921 through 2030.
    a. Compared the effect of applying compost annually for 10 years (1996–2005) at seven different application rates: 1.3, 3.2, 6.5, 10, 15, 20, and 40 wet tons compost/acre.
    b. Simulated varying compost applications: 1.3 and 3.2 wet tons compost/acre annually for 10 years (1996–2005) and every 5 years.
    c. Simulated a scenario with no compost application for each combination of site-fertilization-crop residue management as the control or baseline scenario.

1. Soil Carbon Restoration (cont.)

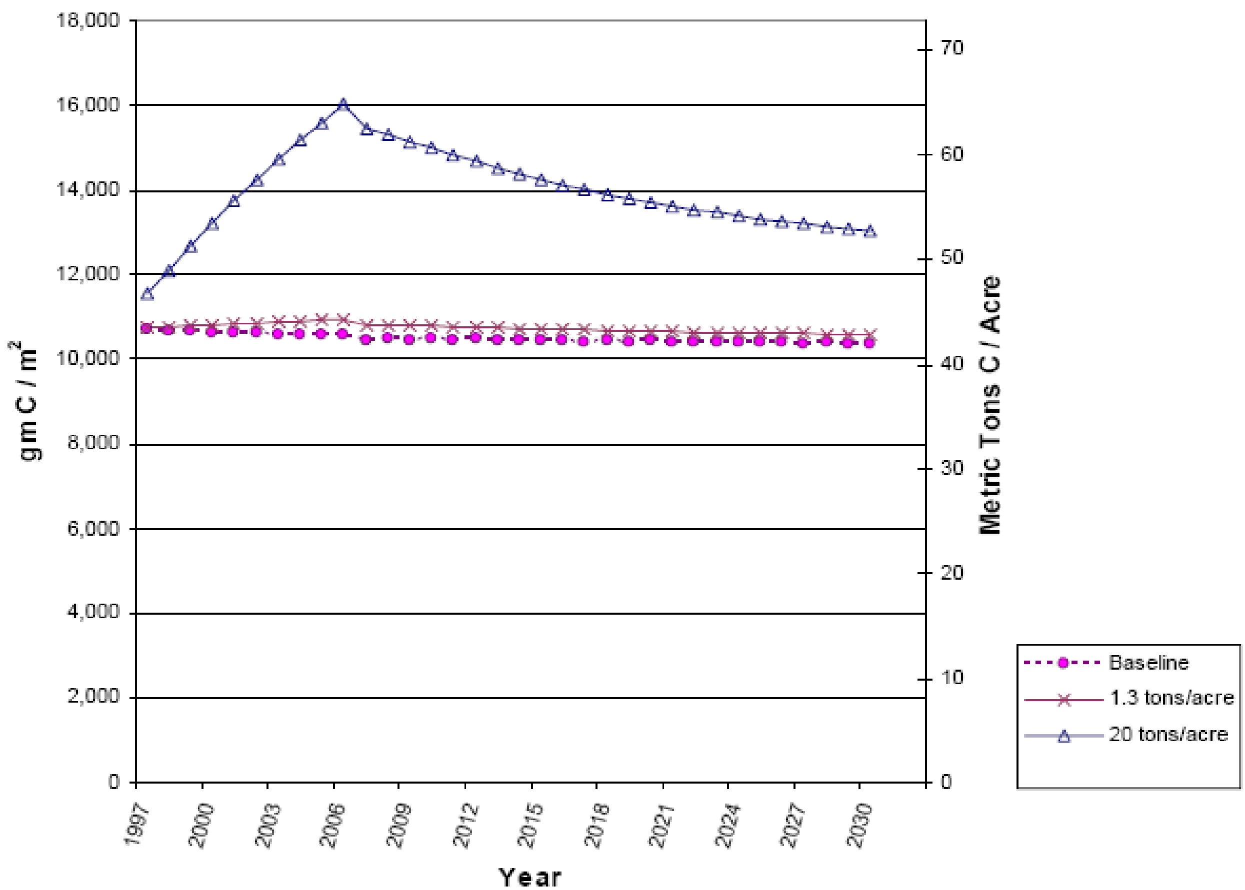
- Key Assumptions on compost composition
  - 21% carbon
  - 33% lignin content
  - *None of the input is passive carbon*
  - 17:1 C:N ratio
  - 60:1 C:P ratio
  - 75:1 C:S ratio.

1. Soil Carbon Restoration (cont.)

- Input specifications
  - Two sites chosen: eastern Colorado with clay loam soil and southwestern Iowa with silty clay loam soil.
  - Varied fertilization rates ranging from 0 to 90 lbs N/acre in Colorado and 0 to 124 lbs N/acre in Iowa.
  - Two harvest regimes simulated including silage (above-ground) and grain harvesting.

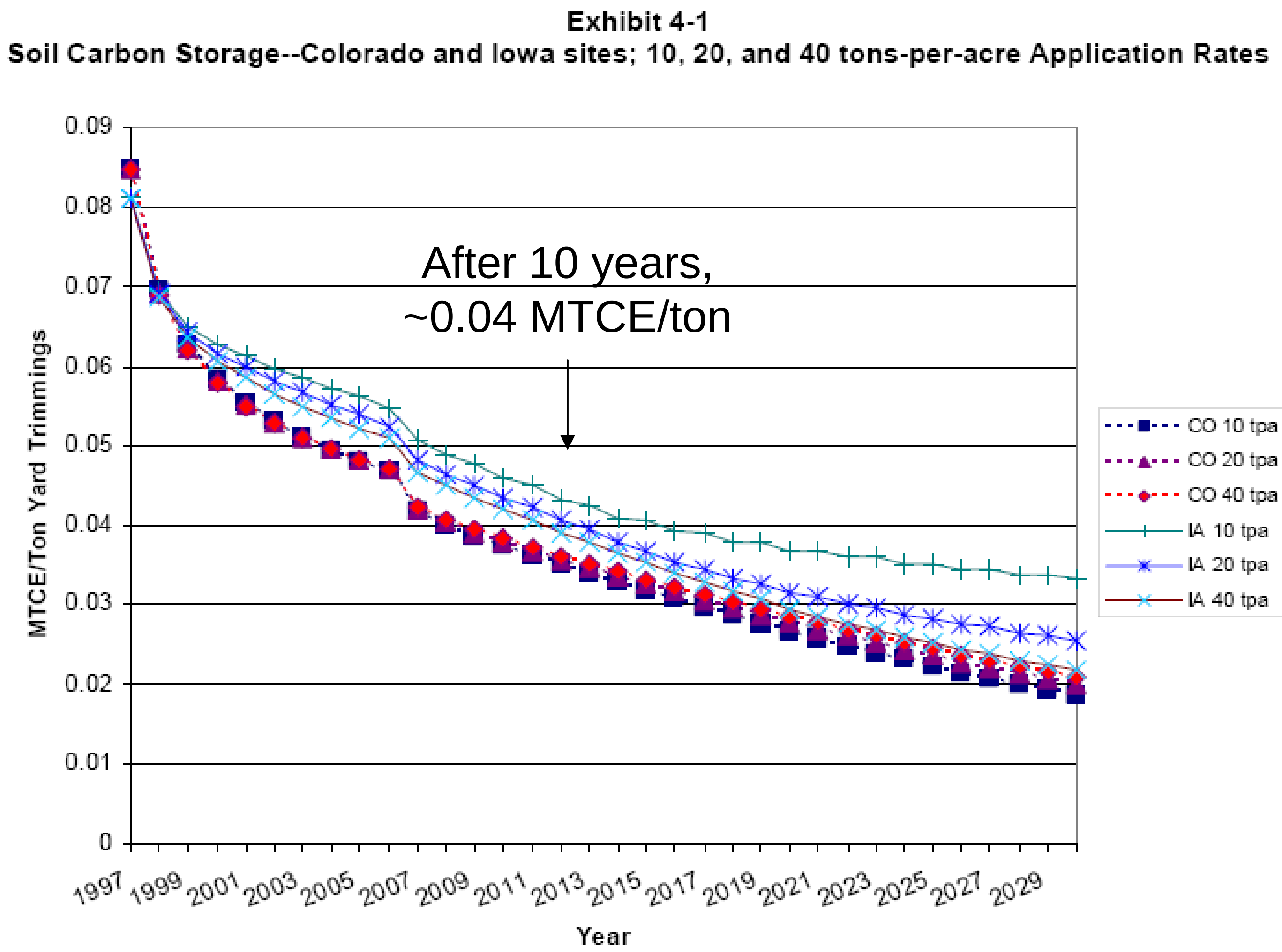
1. Results for Soil Carbon Storage
Total Soil Carbon Perspective

Exhibit 4-3 Total Soil C; Iowa Site, Corn Harvested for Grain



1. Results for Soil Carbon Storage

Storage per ton organic input



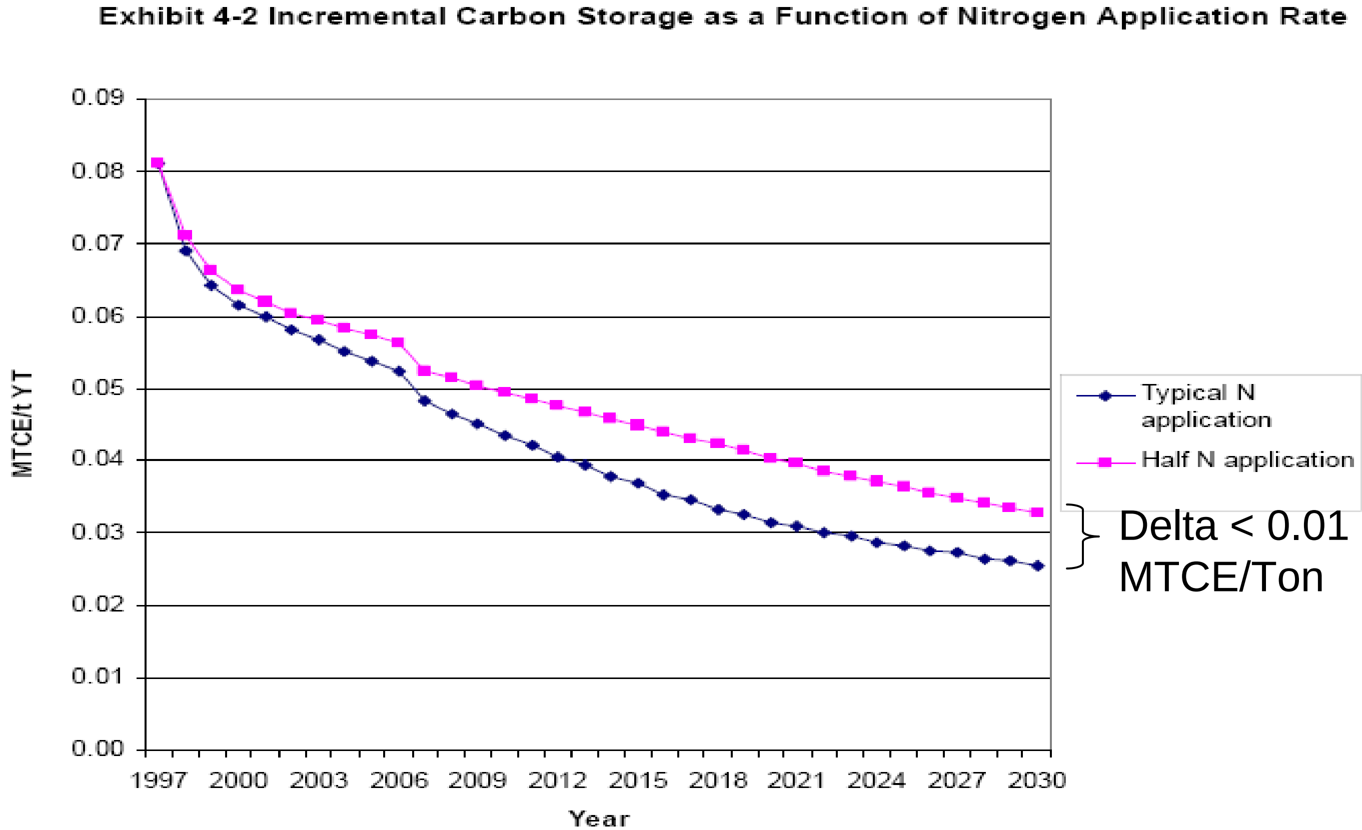
2. Nitrogen Fertilization Effect

- Where shortages of nitrogen exist, compost application could increase crop productivity
- This would translate into higher inputs of crop residues to the soil which would increase the carbon storage rate per compost input

2. Nitrogen Fertilization Effect

- Different rates of synthetic fertilizer addition (from zero through typical rates) were analyzed.
- Carbon storage differential attributable to compost analyzed to estimate the additional biomass produced in response to the nitrogen contributed by the compost.

2. Effect of Nitrogen Application



•Result: The nitrogen effect is relatively small (less than 0.01 MTCE/Ton).

•If farmers continue to apply fertilizer to maintain economic crop yields, effect is negligible.

3. Incremental Humus Formation

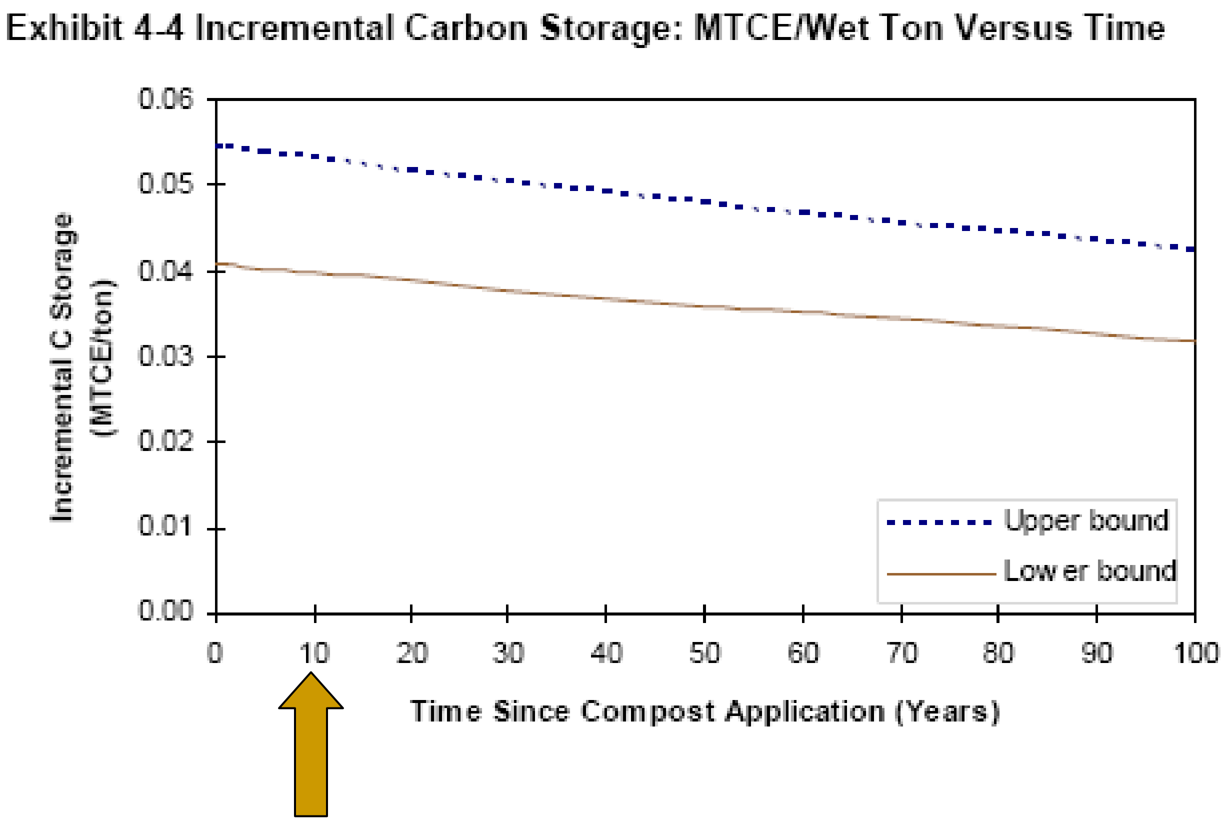
- CENTURY does not model this effect
- Conducted a bounding analysis to estimate the magnitude which is dependent on two main factors:
  A. The amount of carbon in compost that is "passive"
  B. The rate at which the passive carbon degrades to carbon dioxide.

3. Incremental Humus Formation (cont.)

A. Passive carbon in compost is estimated.
   - Literature indicated ~10% of compost carbon is readily degradable and 90% either passive or slow.
   - Upper bound → 30% slow; 60% passive
   - Lower bound → 45% slow; 45% passive

B. Mean residence time for passive carbon
   - Assumed to be 400 years based on a range of values.

3. Incremental Humus Formation (cont. 2)



To select a point estimate for the effect of incremental humus formation, EPA took the average storage value across the two bounding scenarios, when time equals 10 years. The resulting value is 0.046 MTCE/ton.

Net Soil Carbon Storage

- CENTURY simulates incremental effect if all carbon inputs are essentially in the form of additions to the active or slow pools.
  - To avoid double-counting, determined the proportion of carbon that is in the passive pool for the "incremental humus formation" analysis (avg of upper and lower bound scenarios = 48%)
  - Soil carbon results from CENTURY: 48% * -0.04 MTCE/ton = **-0.02 MTCE/ton**
- Incremental Humus Formation: -0.05 MTCE/ton
- Net soil carbon storage = -0.07 MTCE/ton

Gaps and Modeling Limitations

- High-compost load applications possibly can change the equilibrium level of biomass
- Substitution of compost for nitrogen fertilizer.
  - Avoided GHG emissions from production of fertilizers (N, P, and K – based).
  - Avoided CO_2 emissions from urea application.
  - Avoided emissions sensitive to assumed C:N ratio of compost, applicability of compost replacement, amount of organic input required per unit of compost.
  - Assumes 1:1 displacement of inorganic fertilizer.
- Screening analysis on the offset GHG emissions from production and application of nitrogen fertilizer found the effect to be small.

Gaps and Modeling Limitations
N_2O Emissions

- N_2O is potentially generated during composting
- After compost application, some of the nitrogen in compost is released into the atmosphere as N_2O.
- We did not quantify these N_2O emissions from composting because
  - Based on a screening analysis, N_2O emissions were estimated to be less than 0.01 MTCE per wet ton of compost inputs.
  - If compost is used in lieu of nitrogen fertilizer, and if N_2O emissions are a function of N application rate, then the emissions from compost application would equal the emissions in a base case where fertilizer is applied.

Gaps and Modeling Limitations
Backyard Composting

- We did not quantify the GHG benefits of backyard composting, in part due to the large variability in soils and practices.

Gaps and Modeling Limitations
Application to Non-Agricultural Soils

- EPA analysis considers a single compost application (i.e., agricultural soil).
- There is widespread use of compost in land reclamation, silviculture, horticulture, and landscaping.

Gaps and Modeling Limitations
Inclusion of Other Feedstocks

- EPA analyzed only yard trimmings and food discards.
- Sewage sludge, animal manure, and several other compost feedstocks also may have significant GHG implications.

Potential Data/Method Improvements

- Choice of timeframe for carbon storage effect
  - We used a ~10 year time frame between compost application and when we measured the incremental carbon.
- Improvements to CENTURY model
- Additional information on humus formation in compost

Conclusion

- On a per ton basis, soil carbon accumulation is small and emissions are smaller. So net emissions are slightly negative.
- The benefits (soil carbon) are sensitive to the choice of time elapsed since compost is applied.

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