Composting Horse Stable Manure

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Why Compost?

RESOURCE CONSERVATION AND SOIL AND WATER QUALITY!
Land Application of Manure

- Is an acceptable disposal/utilization method,

- but may not address weeds, pathogens or water quality issues
A 1,000 lb. Horse Can Generate:

30-lbs of manure plus 20-lbs of urine/day, or

8-10 tons or 12-15 cubic yards of material annually

Bedding...

At an average 0.75 cubic feet per day, bedding can add 10 cubic yards of waste materials, per horse, to the waste stream annually.
## Average Storage Volume

<table>
<thead>
<tr>
<th>No. of Horses</th>
<th>Manure</th>
<th>Manure w/Bedding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>250 days</td>
<td>Year</td>
</tr>
<tr>
<td></td>
<td>cubic yards</td>
<td>cubic yards</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>35</td>
<td>50</td>
</tr>
<tr>
<td>15</td>
<td>105</td>
<td>150</td>
</tr>
<tr>
<td>25</td>
<td>175</td>
<td>250</td>
</tr>
<tr>
<td>40</td>
<td>280</td>
<td>400</td>
</tr>
</tbody>
</table>

*Assumes 0.75 cu. ft. manure/day and 0.50 to 0.75 cu. ft. bedding/day.
A cubic yard is 27 cu. ft. and occupies a cube 3ft x 3ft x 3ft.
# Typical nutrient content of horse manure (dry weight)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Manure</th>
<th>W/ Bedding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>lbs./ton</td>
</tr>
<tr>
<td>Nitrogen (N)</td>
<td>0.95</td>
<td>19.0</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>0.30</td>
<td>6.0</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>1.50</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.30</td>
</tr>
</tbody>
</table>
What is Compost?

“The product of a managed (aerobic, thermophilic) process through which microorganisms break down plant and animal materials into [more available*] forms suitable for (beneficial) application to the soil.” -USDA NOP

Compost is not fertilizer! It is a soil amendment with soil fertility and soil quality enhancing characteristics.

*Not always!
Most Importantly:

Compost is a source of (solar) energy (carbon) for the soil ecosystem that positively impacts soil-plant-water relations by increasing the water, oxygen and nutrient holding capacity of soils.
Aerobic Composting Process

Raw manure
Bedding
Water

Compost pile

Oxygen

Heat

Water

Carbon dioxide

Finished Compost
Advantages of Aerobic Thermophilic Composting:

- Pathogens exposed to thermophilic temperatures (>131°F) for a sufficient period of time are destroyed (E.coli, SOD, Salmonella, etc.)
- Most weed seeds are killed
- Decomposition is rapid; volume reduction occurs quickly
- Soluble nutrients are converted to organic forms less subject to loss to water or air.
Composting can Reduce Risks To Water Quality posed by Manure:

- Reduction and elimination of microbial pathogens
- Reduction of ammonia N-levels
- Reduction in water-soluble phosphorus and nitrogen
- Reduction of Biological Oxygen Demand (BOD)
- Reduction in soluble salts
Aerobic Composting

Parameters

- **Optimum Carbon/Nitrogen Ratio:**
  25/1 – 40/1

- **Air:** optimize oxygen (bulk density < 40 lbs/ft³)
  
  - Wet dairy manure bd = 65 lbs/ft³
  
  - Horse bedding bd = 20 lbs/ft³

- **Water:** 50-60% moisture- “wrung-out sponge”

- **Temperature:** 131° F minimum (pathogen reduction phase)
Carbon to Nitrogen Ratio

- Relative amount of carbon and nitrogen
- Horse manure alone has C/N ratio of 25/1; optimum for composting
- Carbonaceous bedding has a C/N ratio of 50-100/1, unfavorably increasing the C/N ratio of stable manure compared with horse manure alone.
- Urine helps balance high C bedding.
- C stabilizes N
C/N Ratio:  25/1 – 40/1
Pathogen Reduction Phase

USDA NOP
US EPA
CalRecycle

“... between 131 and 170 degrees (F) for 3 days using an in-vessel or aerated static pile, or ..."

Over-aeration is possible: Cooling, volatilization, overheating, drying
...for 15 days using a (turned) windrow system, during which it...must be turned a minimum of 5 times.”

-NOP/CIWMB

- Animal materials (NOP vs CIWMB)
- Organic Preharvest Interval
Passive Aeration/Static Pile
Static Pile (passive or aerated): Requires an insulating layer of finished compost
Compost Temperatures

- Temperatures usually will increase within 24 hours of pile assembly, and may reach 155°F or more within 2-3 days.

- A compost thermometer (24-48”) and record keeping are essential.
Check temperature at several points at a depth of 24”
Record Keeping

- Process monitoring
- Organic certification
- LEA compliance
Typical Temperature Profile

GV2

Green Waste, Horse and Dairy

Days from Assembly
Fate of fecal bacteria in thermopile

- **Bacteroidales** (dominant gut bacteria)
- **Enterococcus** (fecal indicator)
- **Streptococcus** (sewage pathogen)
- **Aeromonadales** (sewage pathogen)
- **Enterobacteria** (Coliforms, E. Coli, Salmonella)
Site Considerations
Scale Determines Site and Technology Requirements

There must be adequate space to:

- store the anticipated volume of manure and bedding
- provide equipment access and working area
- accommodate active composting and temporary storage of feedstock and final product

Most importantly:

- The site design must protect water quality
Compost Leachate
Basic Components of an On-Farm Composting System

- Located away from creeks and drainage ways;
- Volume large enough to maintain temperatures (> 1 yd$^3$):
- A mechanism for aeration;
- Temperature monitoring
- Available water
- Leachate/runoff accommodation

No single design for an on-farm composting system is appropriate for all sizes and types of facilities.
Basic Site Requirements......

Figure 2. Example of idealized compost site details

- Berm or Ditch flows to Basin
- Compost Pad
- Detention basin
- Slope and Prevailing Wind
- Manure storage
- To Stables
- 150 ft
- 100 ft
- Pony Tail Creek

See detail shown in Fig. 3
Control Runoff

- Controlling runoff and drainage from the compost site
Grassed waterway for filtering runoff
Vegetated filter
between compost pad and water body
All Weather Access
2% slope
Concrete
Asphalt
Road base
Lime-clay
Quarry fines
D.G.
Compost Regulations

“When the country is confused and in chaos, loyal ministers appear” - Lao Tzu

- CalRecycle
- LEA
- NOP/CDFA
- SWRCB/RWQCB

“An activity is excluded (from CalRecycle regulation) if it handles agricultural material derived from an agricultural site, and returns a similar amount of the material produced to that same agricultural site, or an agricultural site owned or leased by the owner, parent, or subsidiary of the composting activity. No more than an incidental amount of up to 1,000 cubic yards of compost product may be given away or sold annually”.

– CCR Title14/ch31, Section 17855
Compost Bins
(@15-20 yds per horse per year...)

![Image of compost bins](image-url)
O2 Compost Micro-bin

- Photo: Peter Moon, 02Compost
Windrows
Pellet Bedding

- May reduce volumes by 20-25%
- Requires less time to compost
- Results in a final product with a lower C:N ratio
When is Compost Finished?

- Temperature: 90-120°F
- Odor pleasant; no ammonia or off odors
- Material is dark in color and uniform in texture
- Bioassays
Herbicides: Clopyralid and Aminopyralid

Most pesticides, including herbicides, break down fairly quickly in the composting process; Clopyralid, Aminopyralid and Aminocyclopyrachlor (Imprelis), do not.

Concentrations as low as 1-3 ppb can be lethal to sensitive plants such as peas, beans, lettuce, spinach, tomatoes and potatoes.

Breakdown very slowly in composts and soils with an estimated half life of 1 - 2 years.

Avoid feed and bedding contaminated with clopyralid and aminopyralid.
Germination Index

(Zucconi et al, 1981)

\[
G.I. = \frac{\text{Rootlet's length in OMW}}{\text{Rootlet's length in water}} \times \frac{\text{Germination in OMW}}{\text{Germination in water}} \times 100. 
\]

In: Tsioulpas, et al, 2002

Relevance depends upon use of final product:
– Eg, seedbed vs permanent pasture.

- Garden Cress (most sensitive)
- Cucumber
- Pea
- Roquette
- Rapini
Compost Use

- 300 cubic yards of bedding manure will produce 150-200 cubic yards of compost
- Which will cover one acre of land with about 1 inch of compost
- ½” is about right for pasture.
2” of compost per acre is about 280 cubic yards or 140 tons. 1-2” per year is about right for Cropland.
Composting Economics

- **Site Development Costs: materials and labor**
- **Quantity of manure with bedding generated (per day, week, month, and year)**
- **Labor required to collect, store, transport to site, compost and manage**
- **Equipment needed (loader, watering system, transport, thermometer)**
- **Equipment maintenance expenses**
- **Other costs (lab samples, permitting, other)**
- **Compost use (on site, trucked away or sold – could be a cost or a return)**
- **Present manure disposal costs**
- **Avoided environmental and regulatory costs**
Summary

- Prepare site to ensure the compost area drains well and does not threaten water quality.
- Collect manure from corrals and pens carefully - conserve bedding.
- Monitor temperature and moisture regularly.
- Make provisions for turning and adding supplemental water when needed.
Composting Summary, Cont...

- Keep the composting area clean and well maintained.
- Conduct laboratory analyses on compost samples initially and if compost procedures or ingredients change.
- Use finished material beneficially as a soil amendment
West Marin Compost provides dumpster delivery and pick-up service for equine waste and bedding materials.

Call 415-662-9849 for set-up information and rates.

http://westmarincompost.org/
Carbon Sequestration and Climate Change

- Even the most effective GHG emissions reductions program will not be enough to avoid catastrophic changes in global ecosystems (IPCC 2014).

- Emission reduction must be accompanied by carbon sequestration on a global scale (Hansen et al 2016).
We can only meet our GHG reduction goals by investing in our soils and working lands as major sinks for atmospheric carbon.

IPCC SPM 2.4 p. 16 (2014): "A large fraction of anthropogenic climate change resulting from CO2 emissions is irreversible on a multi-century to millennial time scale, except in the case of a large net removal of CO2 from the atmosphere over a sustained period."

*hypothetical acceptable maximum
Compost can Reduce Atmospheric CO2

‘... every one tonne increase in soil organic carbon represents 3.67 tonnes of CO2 sequestered from the atmosphere and removed from the greenhouse equation.’

‘For example, a 1% increase in organic carbon in the top 20 cm of soil (with a bulk density of 1.2 g/cm3) represents a 24 t/ha increase in soil OC which equates to 88 t/ha of CO2 sequestered.’

-Dr Christine Jones (2006), Australia

(and roughly 50,000 gallons of increased water holding capacity per acre).
California Cropland Soil Carbon Sequestration Potential With Compost Additions (Compost C Only)

3.96 million hectares (9.8 million acres) of cropland in California: virtually all is suitable for compost application.

At a rate of 3 tons Compost ac⁻¹y⁻¹
= 27 MMT (Tg) CO₂e/y⁻¹

At a rate of 6 tons Compost ac⁻¹y⁻¹
= 54 MMT (Tg) of CO₂e/y⁻¹

At a rate of 20 tons Compost ac⁻¹y⁻¹
= 180 MMT (Tg) of CO₂e/y⁻¹ (and over 27,000 gallons per acre of increased water holding capacity)

Does not include avoided CH₄ or N₂O, or increased photosynthetic capture of CO₂.

• Livestock
  ~ 15 MMT CO₂e y⁻¹

• Commercial/residential
  ~ 42 MMT CO₂e y⁻¹

• Electrical generation
  ~ 112 MMT CO₂e y⁻¹

Assumptions: 1 Mg compost = 0.5 Mg OM = 0.25 Mg OC
Acknowledgements

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Questions?

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Aeration

- **Turned windrow**: base turning frequency on temperature profile and pathogen reduction phase requirements (5 turnings, 15 days).

- **Static pile, forced aeration**: excessive aeration is possible; cooling, N volatilization, overheating, drying.

- **Static pile, passive aeration**: aeration is typically inadequate to achieve complete breakdown in the short term, but can be effective.

- **Daily temperature readings** required during Pathogen Reduction Phase (EPA, CIWMB).
Aerobic Composting
Requirements

- Carbon - Nitrogen Ratio: 25/1 - 40/1

- Air: optimize oxygen

- Water: 50-60% moisture

- Temperature: 131° F minimum