Composting Horse Stable Manure

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With Acknowledgments to “A Horse Keeper's Guide to Manure Management”, USDA-NRCS
Compost

“The product of a managed 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 a fertilizer, but a soil amendment with soil fertility and soil quality enhancing characteristics.”

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
annually

Bedding...

At an average 0.75 cubic feet per day, bedding can add an additional 10 cubic yards of waste materials, per horse, to the waste stream annually.
Typical macro-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>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>
</tbody>
</table>

Guidelines for Handling Manure

- Regular removal of manure
- Keep stalls and paddocks clean and dry
- Leave behind usable bedding
### 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></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.

### Land Application Guidelines

#### Land Application Guidelines

Average manure application and land base area requirements for pasture crops.*

<table>
<thead>
<tr>
<th>Forage Crop</th>
<th>Annual Manure Application tons/acre</th>
<th>Land Area Required acres/horse/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Clover</td>
<td>10</td>
<td>0.8</td>
</tr>
<tr>
<td>Ryegrass</td>
<td>11</td>
<td>0.8</td>
</tr>
<tr>
<td>Tall Fescue</td>
<td>13</td>
<td>0.6</td>
</tr>
<tr>
<td>Wheat Grass</td>
<td>2</td>
<td>3.8</td>
</tr>
</tbody>
</table>

*Adapted from Davis and Swinker, 1996 (assumes 8 tons manure/yr).
Why Compost?

RESOURCE CONSERVATION AND
SOIL AND WATER QUALITY!

Land Application

- Is an acceptable disposal method, but may not address pathogens or water quality

- Composting destroys pathogens and weeds and helps protect water quality.
Advantages of Aerobic Thermophilic Composting:

- Pathogens exposed to thermophilic temperatures (>131°F) for a sufficient period of time are destroyed (E.coli, SOD, etc.)
- Most weed seeds are killed
- Decomposition is rapid; volume reduction occurs quickly

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
- Reduction of Biological Oxygen Demand (BOD)
- Reduction in total soluble salts
Aerobic Composting Process

- Raw manure
- Bedding
- Water
- Oxygen
- Compost pile
- Carbon dioxide
- Heat
- Water
- Finished Compost

Aerobic Composting Requirements

- Carbon and Nitrogen Ratio: 30/1 – 50/1
- Air: optimize oxygen
- Water: 50-60% moisture
- Temperature: 131°F minimum
Carbon to Nitrogen Ratio

- Relative amount of carbon and nitrogen
- Horse manure alone has C/N ratio of 25-35/1; 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 manure alone.

C/N Ratio:  25/1 – 50/1
Aeration

- Turned windrow
- Forced aeration
- Static pile

Aeration Methods

- **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.

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

USDA NOP
US EPA
CIWMB

“… 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 manures (NOP vs CIWMB)
- Organic Preharvest Internal
Passive Aeration/Static Pile

Static Pile: Requires an insulating layer of finished compost

6 Month Old Compost

Reuse of Compost
Compost Recipes:
C/N + Water + Air

Horse manure
Stable shavings
Green waste
Etc.

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)
Raw materials: manure, bedding, spoiled feed....

Mixed Green Material, Kitchen Waste, etc.
## Carbon Compound Characteristics

<table>
<thead>
<tr>
<th>C Compound</th>
<th>Decomposition rate</th>
<th>End Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugars, starches</td>
<td>Fast</td>
<td>CO$_2$, H$_2$O</td>
</tr>
<tr>
<td>Proteins</td>
<td>Fast, Moderate</td>
<td>** N, P, S, CO$_2$**</td>
</tr>
<tr>
<td>Hemicelluloses</td>
<td>Moderate, Slow</td>
<td>Humus</td>
</tr>
<tr>
<td>Cellulose</td>
<td>Slow, Very slow</td>
<td>Humus</td>
</tr>
<tr>
<td>Fats, Waxes, Oils **</td>
<td>Slow, Very slow</td>
<td>Humus</td>
</tr>
<tr>
<td>Lignins, Polyphenols**</td>
<td>Slow, Extremely slow</td>
<td>Humus</td>
</tr>
</tbody>
</table>

**Trouble shooting indicators**

- **McGourty and Reganold, 2005**
Checking 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 equipment
- Temperature should be measured at multiple (2+) locations to a depth of 24”

Check temperature at several points at a depth of 24”
Why Keep Records?

- Process monitoring
- Organic certification
- LEA

Typical Compost Temperature Profile

Green Waste, Horse and Dairy

Days from Assembly
Site Selection and Construction

Operation Size 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 final product

Most importantly:
- The site design must protect water quality
Basic Components of an On-Farm Composting System

- Located away from creeks and drainage;
- Bins or piles large enough to maintain temperatures (> 1 yd$^3$):
- A mechanism for aerating the bins or piles;
- Temperature monitoring
- Available water

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

Basic Site Requirements
All Weather Access

All Weather Compost Pad

2% slope
Concrete
Asphalt
Road base
Lime-clay
Quarry fines
D.G.
Control Runoff

- Controlling runoff and drainage from the compost site is essential

Compost Regulations

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

- CIWMB
- LEA (SOP)
- NOP
- RWQCB

“An activity is excluded (from CIWMB 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”. - CIWMB
Water Quality Regulations

- CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
- REPORT OF WASTE DISCHARGE
- BMP’s
- WAIVER
- [http://www.waterboards.ca.gov/](http://www.waterboards.ca.gov/)

Compost Leachate
A detention basin should be included in the design at the low end of the compost pad to capture and temporarily hold storm water.
Grassed waterway for safe disposition of runoff

Vegetated filter between compost pad and surface water
Bins

Photo: Peter Moon, 02Compost

O2 Compost Micro-bin

Photo: Peter Moon, 02Compost
Windrows
Compost Covers

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 Done?

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

Germination Index

(Zucconi et al, 1981)

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

From: Tsioulpas, et al, 2002

- Relevance depends upon use of final product:
  - seedbed vs permanent pasture.
- Garden Cress
- Roquette
- Rapini
300 cubic yards of manure will produce 150-200 cubic yards of compost, which will cover one acre of land with about 1 inch of compost.

2” of compost per acre is about 300 cubic yards or 150 tons.
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 sample, 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

Composting Summary

- Prepare your 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.
- Use the finished product in your landscapes, planters, and gardens.
- Have laboratory analysis performed on compost samples initially and if compost procedures change.

Global Warming and Soil Carbon Sequestration
Changes in global average surface temperature

Eleven of the last twelve years rank among the twelve warmest years in the instrumental record of global surface temperature

IPCC
Climate Change is a symptom of dysfunctional ecosystem processes.

Carbon dioxide emissions exceed carbon capture

-Abe Collins, Carbon Farmers of America
Carbon Sequestration

- If we ended all greenhouse gas (GHG) emissions tomorrow, atmospheric CO2 would take a hundred years to return to 1985 levels. [IPCC, 2007].
- Even the most effective GHG emissions reductions program will not be enough to avoid catastrophic changes in global ecosystems.
- Such programs **must** be accompanied by *carbon sequestration* on a global scale.

Good News: Soil C Increases 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
How Much C Can Our Soils Hold?

The Marin Carbon Project
Phase 1 – Regional Soil Carbon Survey

- Collect soil to 1 m depth from 35 fields in Marin and Sonoma counties
- Analyze soils for carbon, nitrogen, pH, texture, and carbon fractions
- Determine if patterns in soil carbon pools exist with soil chemical and physical properties, environmental conditions, and/or management

Whendee Silver
University of California, Berkeley

West Marin Co-Composting Project
Carbon Sequestration and Carbon Trading

- Compost has significant potential to rapidly increase rates of carbon sequestration in crop and rangeland soils

Excess Carbon Dioxide in the Atmosphere Can Be Transformed Into Soil Organic Matter Through the Processes of Photosynthesis and Decay. Abe Collins, CarbonFarmersofAmerica.org
The solution to the inextricably linked global crises of:

- food security,
- water availability and
- climate stabilization

lies in the soils beneath our feet.

COMPOST!

Acknowledgements

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