How to Mix Composting Materials: Characteristics & Equations

Introduction

This technical bulletin covers the characteristics of organic materials used in composting and the necessary equations for successfully mixing the materials for compost piles.

Characteristics of Organic Material

Material	N% (dry weight)	C:N Ratio (weight to weight)	Moisture Content % (wet weight)	Bulk Density (lbs/yd^3)	Bulk Density (kg/m^3)
Crop residues and fruit/vegetable-processing wastes					
Apple filter cake	1.2	13	60	1,197	710
Apple pomace	1.1	48	88	1,559	925
Apple-processing sludge	2.8	7	59	1,411	837
Cocoa shells	2.3	22	8	798	473
Coffee grounds	2.28	20	75	-	-
Corn cobs (RANGE)	0.4-0.8	56-123	9-18	-	-
Corn cobs	0.6	98	15	557	330
Corn stalks	0.7	66.5	12	32	19
Cottonseed meal	7.7	7	-	-	-
Cotton gin trash	1.5	19	12	185	110
Cranberry filter cake	2.8	31	50	1,021	606
Cranberry filter cake w/ rice hulls	1.2	42	71	1,298	770
Cranberry plant (stems, leaves)	0.9	61	61	-	-
Cull potatoes	-	18	78	1,540	914
Fruit wastes (RANGE)	0.9-2.6	20-49	62-88	-	-
Fruit wastes	1.4	40	80	-	-
Olive husks	1.35	32.5	9	-	-
Potato-processing sludge	-	28	75	1,570	931
Potato tops	1.5	25	-	-	-
Rice hulls (RANGE)	0-0.4	113-1120	7-12	202	120
Rice hulls	0.3	121	14	202	120

Material	N% (dry weight)	C:N Ratio (weight to weight)	Moisture Content % (wet weight)	Bulk Density (lbs/yd³)	Bulk Density (kg/m³)
Crop residues and fruit/vegetable-processing wastes (Contd.)					
Soybean meal	7.4	5	-	-	-
Sugarcane bagasse	0.67	85	40-50	324	192
Sugarcane filter press mud	1.2	-	60-70	1,200	712
Tomato-processing waste	4.5	11	62	-	-
Vegetable produce	2.7	19	87	1,585	940
Vegetable wastes	3.25	12	-	-	-
Fish and meat processing					
Blood wastes (slaughterhouse waste and dried blood)	13.5	3.25	44	-	-
Crab and lobster wastes (RANGE)	4.6-8.2	4.0-5.4	35-61	-	-
Crab and lobster wastes	6.1	4.9	47	240	142
Fish-breading crumbs	2	28	10	-	-
Fish-processing sludge	6.8	5.2	94	-	-
Fish wastes (gurry, racks, etc.) (RANGE)	6.5-14.2	2.6-5.0	50-81	-	-
Fish wastes (gurry, racks, etc.)	10.6	3.6	76	-	-
Mixed slaughterhouse waste	8.50	3	-	-	-
Mussel wastes	3.6	2.2	63	-	-
Poultry carcasses	2.4	5	65	-	-
Paunch manure	1.8	25	82.5	1,460	866
Shrimp wastes	9.5	3.4	78	-	-
Manures					
Broiler litter (RANGE)	1.6-3.9	12-15	22-46	756-1,026	-
Broiler litter	2.7	14	37	864	513
Cattle (RANGE)	1.5-4.2	11-30	67-87	1,323-1,674	-
Cattle manure	2.4	19	81	1,458	865
Dairy tie stall manure	2.7	18	79	-	-
Dairy free stall manure	3.7	13	83	-	-
Horse-general (RANGE)	1.4-2.3	22-50	59-79	1,215-1,620	-
Horse-general manure	1.6	30	72	1,379	818
Horse-race track (RANGE)	0.8-1.7	29-56	52-67	-	-
Horse-race track manure	1.2	41	63	-	-
Laying hens (RANGE)	4-10	3-10	62-75	1,377-1,620	-
Laying hens manure	8	6	69	1,479	877

Material	N% (dry weight)	C:N Ratio (weight to weight)	Moisture Content % (wet weight)	Bulk Density (lbs/yd^3)	Bulk Density (kg/m^3)
Manures (Contd.)					
Sheep (RANGE)	1.3-3.9	13-20	60-75	-	-
Sheep manure	2.7	16	69	-	-
Swine (RANGE)	1.9-4.3	9-19	65-91	-	-
Swine manure	3.1	14	80	-	-
Turkey litter	2.6	16	26	783	465
Municipal wastes*					
Garbage (food waste)	2.4	15	69	1585	940
Night soil	6	8	-	-	-
Paper from domestic refuse	0.225	152.5	19	-	-
Pharmaceutical wastes	2.6	19	-	-	-
Refuse (mixed food, paper, etc.)	0.95	57	-	-	-
Sewage sludge (RANGE)	2-6.9	5-16	72-84	1,075-1,750	-
Activated sludge	5.6	6	78	-	-
Digested sludge	1.9	16	78	-	-
Straw, hay, silage					
Corn silage	1.3	40.5	66.5	-	-
Hay-general (RANGE)	0.7-3.6	15-32	8-10	-	-
Hay-general	2.1	23.5	9	-	-
Hay-legume (RANGE)	1.8-3.6	15-19	-	-	-
Hay-legume	2.5	16	0	-	-
Hay-non-legume (RANGE)	0.7-2.5	-	-	-	-
Hay-non-legume	1.3	32	0	-	-
Straw-general (RANGE)	0.3-1.1	48-150	4-27	58-378	-
Straw-general	0.7	80	12	227	135
Straw-oat (RANGE)	0.6-1.1	48-98	-	-	-
Straw-oat	0.9	60	0	227	135
Straw-wheat (RANGE)	0.3-0.5	100-150	-	-	-
Straw-wheat	0.4	127	0	227	135
Wood and paper					
Bark-hardwoods (RANGE)	0.10-0.41	116-436	-	-	-
Bark-hardwoods	0.241	223	0	-	-
Bark-softwoods (RANGE)	0.04-0.39	131-1,285	-	-	-
Bark-softwoods	0.14	496	0	-	-

Material	N% (dry weight)	C:N Ratio (weight to weight)	Moisture Content % (wet weight)	Bulk Density (lbs/yd^3)	Bulk Density (kg/m^3)
Wood and paper (Contd.)					
Corrugated cardboard	0.1	563	8	259	154
Lumbermill waste	0.13	170	0	-	-
Newsprint	0.1	625	5.50	218.5	130
Paper fiber sludge	-	250	66	1140	676
Paper mill sludge	0.56	54	81	-	-
Paper pulp	0.59	90	82	1403	832
Sawdust (RANGE)	0.06-0.8	200-750	19-65	350-450	-
Sawdust	0.24	442	39	410	243
Telephone books	0.7	772	6	250	148
Wood chips	-	-	-	532.5	316
Wood-hardwoods	0.06-0.11	451-819	-	-	-
Hardwood (chips, shavings, etc.)	0.09	560	0	532.5	316
Wood-softwoods	0.04-0.23	212-1,313	-	-	-
Softwood (chips, shavings, etc.)	0.09	641	0	532.5	316
Yard wastes and other vegetation**					
Grass clippings (RANGE)	2.0-6.0	9-25	-	-	-
Grass clippings	3.4	17	82	-	-
Grass clippings, Loose	3.4	17	82	350	208
Grass clippings, Compacted	3.4	17	82	650	386
Leaves (RANGE)	0.5-1.3	40-80	-	-	-
Leaves	0.9	54	38	-	-
Leaves, Loose and dry	0.9	54	15	200	119
Leaves, Compacted and moist	0.9	54	38	450	267
Seaweed (RANGE)	1.2-3.0	5-27	-	-	-
Seaweed	1.9	17	53	-	-
Shrub trimmings	1	53	15	429	255
Tree trimmings	3.1	16	70	1,296	769
Water hyacinth-fresh	-	25	93	405	240
Water	0	0	100	1682	998
Urine	0.935	0.8	94.5	1722.3	1,022

* Prior to incorporating materials from a waste water treatment system into a compost, they must first be analyzed for heavy metals that can pose serious health concerns. Septic materials must be declared safe in order to be used for composting. The septic must be pumped out into a screen to remove the solids from the liquids. Store the solids in a contained area e.g., a pit, and the liquid in a separate container e.g., a tank. Be sure to wear Personal Protective Equipment (PPE) to avoid contact with any pathogens.

** When using yard wastes, leaves, and grass clipping, make sure they are not treated with pesticides and/or herbicides.

Equations for Mixing Materials

% Moisture Content

$$\% \text{ Moisture Content} = \frac{\text{Wet weight - dry weight}}{\text{Wet weight}} \times 100$$

Moisture Content (wt.)

$$\text{Moisture Content (wt.)} = \frac{\% \text{ Moisture}}{100}$$

Dry Weight

Dry Weight = Total weight - Weight of water

Nitrogen Content

Nitrogen Content = Dry Weight x (%N/100)

Carbon Content

Carbon Content = Dry Weight x (%C/100)

Carbon Nitrogen Ratio

$$\text{Carbon Nitrogen Ratio (C:N)} = \frac{\text{Carbon Content}}{\text{Nitrogen Content}}$$

Equations for Mixing Materials

1 Mix Moisture

$$\frac{\text{Wt. of water in material A + water in B + water in C + ...}}{\text{Total weight of all material}} = \text{Mix Moisture}$$

Weight of water to be added

$$M^x = \frac{W\,(M^d - M^i)}{(1 - M^d)}$$

Symbols:
M^x = Amount of water to be added (tons)
M^d = Desired moisture content, % total weight / 100
M^i = Initial material moisture content / 100
W = Initial feedstock weight, tons including water

2 C:N Ratio

$$\frac{\text{Wt. of "C" in material A + "C" in B + "C" in material C}}{\text{Wt. of "N" in material A + "N" in B + "N" in C}} = \text{C:N Ratio}$$

Required amount of material A per pound of material B based on the desired moisture content

$$\frac{\text{Moisture of material B - Desired moisture}}{\text{Desired moisture - Moisture of material A}} = \text{Weight of material A}$$

Now check the C:N ratio using this equation

Required amount of material A per pound of material B based on the desired C:N Ratio

$$\text{Weight of Material A} = \frac{\%N^b}{\%N^a} \times \frac{(R - R^b)}{(R^a - R)} \times \frac{(1 - M^b)}{(1 - M^a)}$$

Symbols:
A = pounds of material A per pound of material B
M^a = Moisture content of material A
M^b = Moisture content of material B
% N^a = % Nitrogen in material A
% N^b = % Nitrogen in material B
R = Desired C:N ratio
R^a = C:N ratio of material A
R^b = C:N ratio of material B

Check moisture content using equation 1

Recipe Sample Calculation

Given

Chicken Manure		***Sawdust***	
Moisture	*70%*	*Moisture*	*35%*
Nitrogen	*6%*	*Nitrogen*	*0.11%*
C:N Ratio	*10:1*	*C:N Ratio*	*500:1*

Blend to the desired moisture content.

Imperial

1 pound manure (M) contains:

Water = 0.7 lb
Dry Matter = 0.3 lb
Nitrogen = (0.3 x 0.06) = 0.018 lb
Carbon = (0.018 x 10) = 0.18 lb

1 pound sawdust (S) contains:

Water = 0.35 lb
Dry Matter = 0.65 lb
Nitrogen = (0.65 x 0.0011) = 0.00072 lb
Carbon = (0.00072 x 500) = 0.36 lb

Metric

1 kilogram manure (M) contains:

Water = 0.7 kg
Dry Matter = 0.3 kg
Nitrogen = (0.3 x 0.06) = 0.018 kg
Carbon = (0.018 x 10) = 0.18 kg

1 kilogram sawdust (S) contains:

Water = 0.35 kg
Dry Matter = 0.65 kg
Nitrogen = (0.65 x 0.0011) = 0.00072 kg
Carbon = (0.00072 x 500) = 0.36 kg

Use the mix moisture equation

$$\frac{\text{Wt. of water in manure + wt. of water in sawdust}}{\text{Total weight}} = \text{Moisture Content}$$

Imperial

$$MC = \frac{0.07 + (0.35 \times S)}{1 + S}$$

Assume moisture content = 60%

$(0.60)(1 + S) = 0.7 + 0.35S$

$0.60 + 0.60S = 0.7 + 0.35S$

$0.25S = 0.1$

$S = 0.4$ lb sawdust per lb manure

Metric

$$MC = \frac{0.07 + (0.35 \times S)}{1 + S}$$

Assume moisture content = 60%

$(0.60)(1 + S) = 0.7 + 0.35S$

$0.60 + 0.60S = 0.7 + 0.35S$

$0.25S = 0.1$

$S = 0.4$ kg sawdust per kg manure

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