Characterizing Compost and Anaerobic Digestion Products

Presented by:

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1/26/10

What are you selling?

..a *'product'* or just *'brown'* stuff ?

The marketplace has become more sophisticated

Buyer's Requirements

What are they willing to buy?

Soil Incorporant

- **Agricultural crop estab.**
- **Turf establishment**
- **Garden bed preparation**
- **Reclamation/remediation**
- **Nursery production**
- **Roadside Vegetation**

Growing Media Component

- **Container/potting substrates**
- **Landscape (e.g. rooftop, raised planters)**
- **Backfill mixes (tree/shrub)**
- **Golf course (e.g. tee, green, divot mixes)**
- **Manufactured topsoil**

Buyers have different requirements

Monitor Product Quality & Process

INTERNAL PURPOSES

- Assists in optimizing the composting process
- Generate data for use in facility problem solving
- QA/QC

EXTERNAL PURPOSES

- Illustrate product characteristics & consistency
- Generate data crucial for product sales
- QA/QC - *Certification programs are helpful*

Uniform/Appropriate Level of Testing

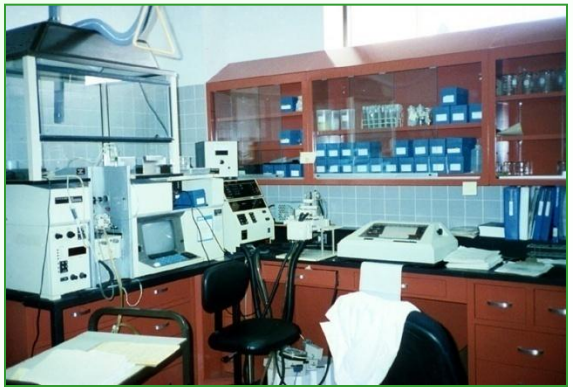
Compost Parameters
pH
Electrical Conductivity
Nutrient Content (N-P-K / Ca, Mg, S)
Moisture Content
Organic Matter Content
Particle Size
Heavy Metals
Pathogens
Stability
Plant Response (Maturity)

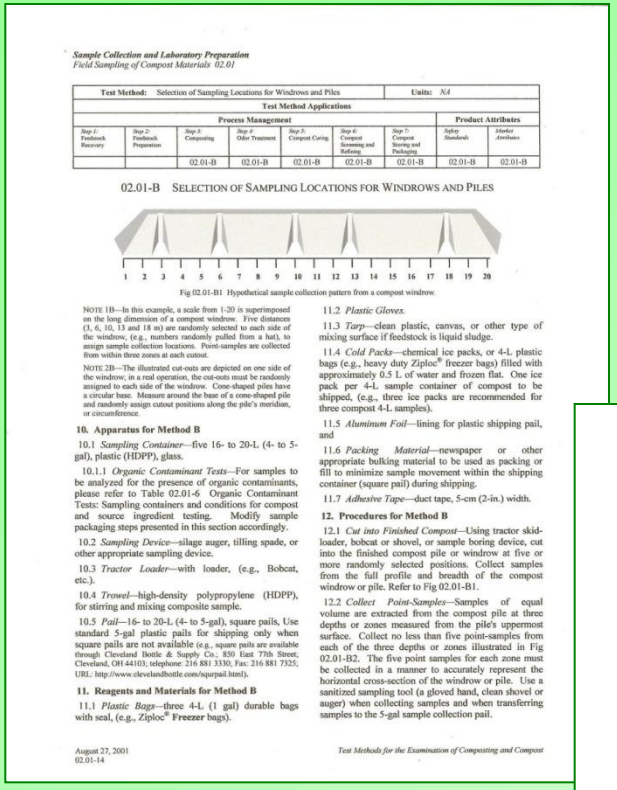
What should I test for? Depends on end use
Still struggling to get industry to test properly

STA Approved Labs

- A&L Canada Laboratories – London, Ontario, Canada
- A&L Great Lakes Labs, Inc. – Ft. Wayne, IN
- A& L Western Laboratories, Modesto, CA
- Ag Analytical Services Lab – State College, PA
- Colorado Analytical Laboratories, Brighton, CO
- Midwest Laboratories, Omaha, NE
- Soil Control Lab – Watsonville, CA
- Soil Test Farm Consultants, Moses Lake, WA
- Woods End Laboratories – Mt. Vernon, ME

Use an experienced 'organics' lab !





Sample Collection and Laboratory Preparation
Field Sampling of Compost Materials 02.01

Test Method: Selection of Sampling Locations for Windrows and Piles						Units: NA		
Test Method Applications								
Process Management							Product Attributes	
Step 1: Feedstock Recovery	Step 2: Feedstock Preparation	Step 3: Composting	Step 4: Odor Treatment	Step 5: Compost Curing	Step 6: Compost Screening and Refining	Step 7: Compost Storing and Packaging	Safety Standards	Market Attributes
		02.01-B	02.01-B	02.01-B	02.01-B	02.01-B	02.01-B	02.01-B

02.01-B SELECTION OF SAMPLING LOCATIONS FOR WINDROWS AND PILES

Fig 02.01-B1 Hypothetical sample collection pattern from a compost windrow.

NOTE 1B—In this example, a scale from 1-20 is superimposed on the long dimension of a compost windrow. Five distances (3, 6, 10, 13 and 18 m) are randomly selected to each side of the windrow, (e.g., numbers randomly pulled from a hat), to assign sample collection locations. Point-samples are collected from within three zones at each cutout.

NOTE 2B—The illustrated cut-outs are depicted on one side of the windrow; in a real operation, the cut-outs must be randomly assigned to each side of the windrow. Cone-shaped piles have a circular base. Measure around the base of a cone-shaped pile and randomly assign cutout positions along the pile's meridian, or circumference.

10. Apparatus for Method B

10.1 *Sampling Container*—five 16- to 20-L (4- to 5-gal), plastic (HDPP), glass.

10.1.1 *Organic Contaminant Tests*—For samples to be analyzed for the presence of organic contaminants, please refer to Table 02.01-6 Organic Contaminant Tests: Sampling containers and conditions for compost and source ingredient testing. Modify sample packaging steps presented in this section accordingly.

10.2 *Sampling Device*—silage auger, tilling spade, or other appropriate sampling device.

10.3 *Tractor Loader*—with loader, (e.g., Bobcat, etc.).

10.4 *Trowel*—high-density polypropylene (HDPP), for stirring and mixing composite sample.

10.5 *Pail*—16- to 20-L (4- to 5-gal), square pails, Use standard 5-gal plastic pails for shipping only when square pails are not available (e.g., square pails are available through Cleveland Bottle & Supply Co.; 850 East 77th Street, Cleveland, OH 44103; telephone 216 881 3330; Fax: 216 881 7325; URL: http://www.clevelandbottle.com/squrpail.html).

11. Reagents and Materials for Method B

11.1 *Plastic Bags*—three 4-L (1 gal) durable bags with seal, (e.g., Ziploc® **Freezer** bags).

11.2 *Plastic Gloves.*

11.3 *Tarp*—clean plastic, canvas, or other type of mixing surface if feedstock is liquid sludge.

11.4 *Cold Packs*—chemical ice packs, or 4-L plastic bags (e.g., heavy duty *Ziploc®* freezer bags) filled with approximately 0.5 L of water and frozen flat. One ice pack per 4-L sample container of compost to be shipped, (e.g., three ice packs are recommended for three compost 4-L samples).

11.5 *Aluminum Foil*—lining for plastic shipping pail, and

11.6 *Packing Material*—newspaper or other appropriate bulking material to be used as packing or fill to minimize sample movement within the shipping container (square pail) during shipping.

11.7 *Adhesive Tape*—duct tape, 5-cm (2-in.) width.

12. Procedures for Method B

12.1 *Cut into Finished Compost*—Using tractor skid-loader, bobcat or shovel, or sample boring device, cut into the finished compost pile or windrow at five or more randomly selected positions. Collect samples from the full profile and breadth of the compost windrow or pile. Refer to Fig 02.01-B1.

12.2 *Collect Point-Samples*—Samples of equal volume are extracted from the compost pile at three depths or zones measured from the pile's uppermost surface. Collect no less than five point-samples from each of the three depths or zones illustrated in Fig 02.01-B2. The five point samples for each zone must be collected in a manner to accurately represent the horizontal cross-section of the windrow or pile. Use a sanitized sampling tool (a gloved hand, clean shovel or auger) when collecting samples and when transferring samples to the 5-gal sample collection pail.

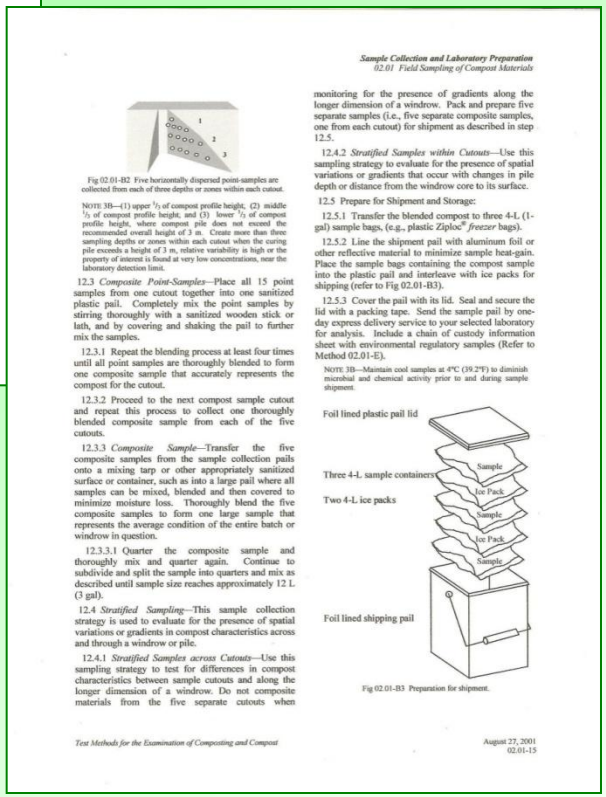


Fig 02.01-B2 Five horizontally dispersed point-samples are collected from each of three depths or zones within each cutout.

NOTE 3B—(1) upper ⅓ of compost profile height, (2) middle ⅓ of compost profile height, and (3) lower ⅓ of compost profile height, where compost pile does not exceed the recommended overall height of 3 m. Create more than three sampling depths or zones within each cutout when the curing pile exceeds a height of 3 m, relative variability is high or the property of interest is found at very low concentrations, near the laboratory detection limit.

12.3 *Composite Point-Samples*—Place all 15 point samples from one cutout together into one sanitized plastic pail. Completely mix the point samples by stirring thoroughly with a sanitized wooden stick or lath, and by covering and shaking the pail to further mix the samples.

12.3.1 Repeat the blending process at least four times until all point samples are thoroughly blended to form one composite sample that accurately represents the compost for the cutout.

12.3.2 Proceed to the next compost sample cutout and repeat this process to collect one thoroughly blended composite sample from each of the five cutouts.

12.3.3 *Composite Sample*—Transfer the five composite samples from the sample collection pails onto a mixing tarp or other appropriately sanitized surface or container, such as into a large pail where all samples can be mixed, blended and then covered to minimize moisture loss. Thoroughly blend the five composite samples to form one large sample that represents the average condition of the entire batch or windrow in question.

12.3.3.1 Quarter the composite sample and thoroughly mix and quarter again. Continue to subdivide and split the sample into quarters and mix as described until sample size reaches approximately 12 L (3 gal).

12.4 *Stratified Sampling*—This sample collection strategy is used to evaluate for the presence of spatial variations or gradients in compost characteristics across and through a windrow or pile.

12.4.1 *Stratified Samples across Cutouts*—Use this sampling strategy to test for differences in compost characteristics between sample cutouts and along the longer dimension of a windrow. Do not composite materials from the five separate cutouts when monitoring for the presence of gradients along the longer dimension of a windrow. Pack and prepare five separate samples (i.e., five separate composite samples, one from each cutout) for shipment as described in step 12.5.

12.4.2 *Stratified Samples within Cutouts*—Use this sampling strategy to evaluate for the presence of spatial variations or gradients that occur with changes in pile depth or distance from the windrow core to its surface.

12.5 Prepare for Shipment and Storage:

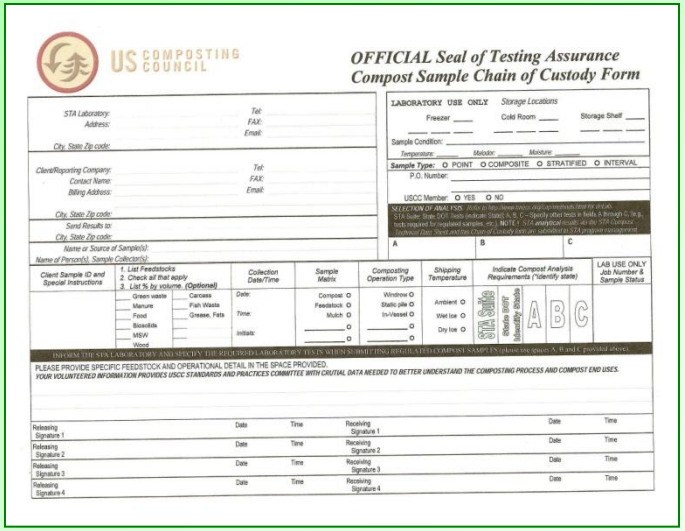
12.5.1 Transfer the blended compost to three 4-L (1-gal) sample bags, (e.g., plastic Ziploc® *freezer* bags).

12.5.2 Line the shipment pail with aluminum foil or other reflective material to minimize sample heat-gain. Place the sample bags containing the compost sample into the plastic pail and interleave with ice packs for shipping (refer to Fig 02.01-B3).

12.5.3 Cover the pail with its lid. Seal and secure the lid with a packing tape. Send the sample pail by one-day express delivery service to your selected laboratory for analysis. Include a chain of custody information sheet with environmental regulatory samples (Refer to Method 02.01-E).

NOTE 3B—Maintain cool samples at 4°C (39.2°F) to diminish microbial and chemical activity prior to and during sample shipment.

Fig 02.01-B3 Preparation for shipment.



US COMPOSTING COUNCIL

OFFICIAL Seal of Testing Assurance
Compost Sample Chain of Custody Form

STA Laboratory:
Address:
City, State Zip code:
Tel:
FAX:
Email:

Client/Reporting Company:
Contact Name:
Billing Address:
City, State Zip code:
Tel:
FAX:
Email:

Send Results to:
City, State Zip code:
Name or Source of Sample(s):
Name of Person(s) Sample Collector(s):

LABORATORY USE ONLY Storage Locations
Freezer ____ Cold Room ____ Storage Shelf ____
Sample Condition:
Temperature: Moisture: Moisture:
Sample Type: O POINT O COMPOSITE O STRATIFIED O INTERVAL
P.O. Number:
USCC Member: O YES O NO
SELECTION OF ANALYSIS: Refer to http://www.tmecc.org/cgi-tech/sub.html for details.
STA Suite: Base, DOT, Tests indicate Stable A, B, C – Specify other tests in fields. A through G, Hg, Inrt, required for regulated samples, etc.). NOTE 1: STA analytical results on the STA Compost Analysis Data Sheet and the Chain of Custody form are substitutes in STA program management

Client Sample ID and Special Instructions	1. List Feedstocks 2. Check all that apply 3. List % by volume. (Optional)	Collection Date/Time	Sample Matrix	Composting Operation Type	Shipping Temperature	Indicate Compost Analysis Requirements ("Identify state)	LAB USE ONLY Job Number & Sample Status
	Green waste ___ Carcass Manure ___ Fish Waste Food ___ Grease, Fats Biosolids ___ MSW ___ Wood ___	Date: Time: Initials:	Compost O Feedstock O Mulch O _____ O _____ O	Windrow O Static pile O In-Vessel O _____ O _____ O	Ambient O Wet Ice O Dry Ice O	STA Suite: Base, DOT, Stable, Inert, Biosolids, Woods A B C	

INFORM THE STA LABORATORY AND SPECIFY THE REQUIRED LABORATORY TESTS WHEN SUBMITTING REGULATED COMPOST SAMPLES (place ice space, A, B and C provided above).

PLEASE PROVIDE SPECIFIC FEEDSTOCK AND OPERATIONAL DETAIL IN THE SPACE PROVIDED.
YOUR VOLUNTEERED INFORMATION PROVIDES USCC STANDARDS AND PRACTICES COMMITTEE WITH CRUTIAL DATA NEEDED TO BETTER UNDERSTAND THE COMPOSTING PROCESS AND COMPOST END USES.

Releasing Signature 1	Date	Time	Receiving Signature 1	Date	Time
Releasing Signature 2	Date	Time	Receiving Signature 2	Date	Time
Releasing Signature 3	Date	Time	Receiving Signature 3	Date	Time
Releasing Signature 4	Date	Time	Receiving Signature 4	Date	Time

Use proper lab test methods, sampling and sample handling procedures

Compost Certification and Registration

Helping to promote and justify proper/on-going testing

R. Alexander Associates, Inc.
OVER 25 YEARS OF SERVICE
TO THE COMPOSTING AND ORGANICS RECYCLING INDUSTRY

Organic Matter Based By-Products / Feedstocks

- **Municipal**
- **Industrial**
- **Agricultural**
- **Energy**
- **Other**

Understand that incoming feedstock(s) affects finished product characteristics

Factors Affecting Product Characteristics

- **Feedstocks**
- **Composting / AD processes**
- **Post processes**

Compost Characterization

Poor job as an industry collecting and analyzing (studying) data, STA change

National Compost Data

	Moisture	Organic Matter	Ash %	Bulk Density	pH	EC5	Carbonate	Germination	Vigor
	%	% Dry wt	% Dry wt	lb/cu ft wet		dS/m	as CaCO3 lb/ton dry	% relative to pos. control	% relative to pos. control
MIN	0.8	1.1	1.0	7.9	3.5	0.1	0.0	0.0	0.0
MAX	88.3	99.0	98.9	101.6	12.1	61.6	1401.3	100.0	100.0
AVE	39.1	46.7	53.3	41.9	7.7	6.0	24.5	80.0	84.2

Important to track industry trends, but needs to evaluated by feedstock, geography, etc.

Compiled data (1 lab)

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National Compost Data

	N	C	C/N Ratio	NH_4-N	NO_3-N	Organic N	P	K	Ca	Mg	SO_4
	% Dry wt	% Dry wt		mg/kg dry wt	mg/kg dry wt	% Dry wt	mg/kg Dry wt	% Dry wt	% Dry wt	% Dry wt	mg/kg dry wt
MIN	0.0	0.1	2.8	0.0	0.0	0.0	67.9	0.0	0.0	0.0	5.0
MAX	13.3	94.6	517,200	1.9	1.1	13.3	84,768	4.8	51.8	11.6	560,000
AVE	1.7	25.0	271.8	0.1	0.0	1.7	6252.2	0.9	3.7	0.6	3,913

Nutrient data very important to ag (& other) markets
Evaluate quality of data, remove outliers, etc.

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Single Composting Facility Compiled Data

Characteristics	Units of Measure		Average	Min	Max
NUTRIENTS					
Total Nitrogen	%, wet wt. basis		0.61	0.41	0.78
Ammonia (NH_4)	ppm, wet wt. basis		395.05	9.70	980
Nitrate (NO_3)	ppm, wet wt. basis		141.92	3.00	420
Org. Nitrogen	%, wet wt. basis		0.56	0.39	0.75
Phosphorus (P_2O_5)	%, wet wt. basis		1.01	0.76	1.3
Potassium (K_2O)	%, wet wt. basis		0.52	0.43	0.63
Calcium	%, wet wt. basis		4.93	3.60	6.4
Magnesium	%, wet wt. basis		0.35	0.29	0.4
Sulfate (SO_4-S)	%, wet wt. basis		1,711.54	650.00	2400
Iron	%, dry wt. basis		19,077	14,000	24,000

Compiled for ease of evaluation, and to understand trends, consistency, etc.

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OTHER PARAMETERS	Units of Measure		Average	Min	Max
PHYSICAL					
Moisture	%, wet wt. basis		**37.84**	**29.80**	**47.3**
Organic Matter	%, dry wt. basis		**30.73**	**25.80**	**46.4**
Bulk Density	Lbs/cubic yard wet wt.		**53.38**	**41.00**	**85**
pH Value	Units		**7.27**	**6.94**	**7.73**
Electrical Conductivity	dS/m2 (mmhos/cm), dry wt. basis		**4.97**	**2.70**	**6.5**
Particle size	% passing 9.5mm sieves, dry wt. basis		**98.37**	**87.00**	**100**
C:N Ratio	Ratio		**16.77**	**13.00**	**25**
BIOLOGICAL					
Stability	mg CO2-C/g OM/day		**1.18**	**0.20**	**2.8**
Maturity – Emergence	average % of control		**100.00**	**100.00**	**100**
Maturity – Vigor	average % of control		**95.25**	**80.00**	**100**

Understand what you are producing / selling, who to sell to
Get help interpreting (opinions, interests in data differ)

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TO THE COMPOSTING AND ORGANICS RECYCLING INDUSTRY

Consumer Use Program Lawn Class

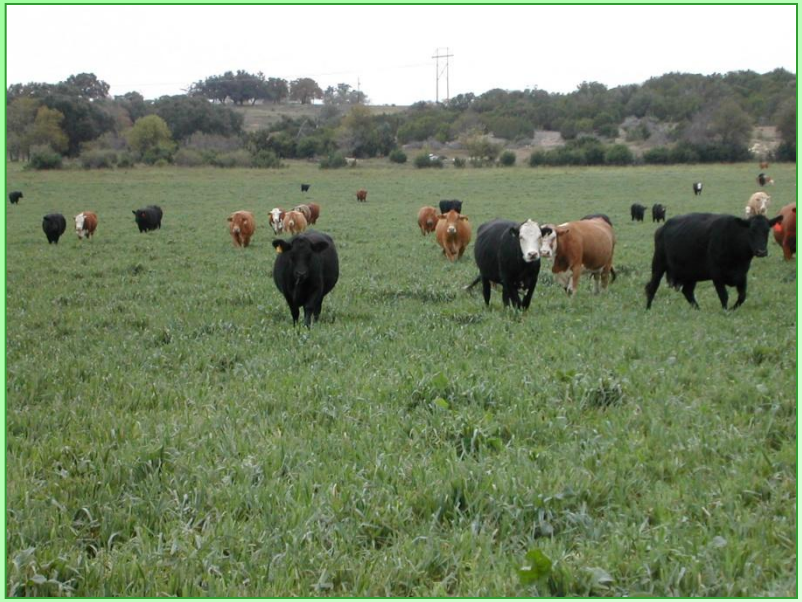
Parameter				
		Preferred	General	
pH	pH units	**6.0-7.5**	**5.5 – 8.5**	Modify soil pH with lime, etc., if necessary, based on soil testing results.
Soluble Salts (Electrical Conductivity)	dS/m (mmhos/cm) dry weight basis	**Maximum of 5**	**Maximum of 15**	Keep in mind that soluble salts are also plant nutrients. Compost containing a higher soluble salt content should be applied at lower application rates, and 'watered in' well.
Moisture Content	% wet weight basis	**40-50%**	**35-65%**	Products with higher moisture contents may be used, they may simply be more difficult to spread
Organic Matter Content	% dry weight basis	**35-50%**	**25-65%**	Creating a soil containing 5 – 10% organic matter is desirable in typical, well drained soils.
Particle Size	Screen size to pass through	**3/8"**	**½"**	Compost topdressing should be screened through a ¼ - 3/8" screen, depending on grass mowing height.
Stability	mg CO_2-C per g OM per day	**<2**	**<4**	The lower the number, the more completely composted
Maturity	% seed emergence & vigor	**90-100**	**80-100**	The higher the percentage the better
Physical Contaminants*	% dry weight basis	**<0.5%**	**<1%**	Small stones may be deemed more acceptable than man-made inerts (e.g., plastic)

Can you meet product spec of buyers?
More spec coming, helps in expanding markets

Remember, not all composts are alike !

Primary Feedstock	Wood Compost	MSW Compost	Yard Trimmings Compost	Cotton Boll Compost	Cattle manure Compost
PHYSICAL					
Moisture Content (%)	28.3	36.1	30.7	38.4	29.8
Total Solids (%)	71.8	64.2	69.4	61.8	70.2
CHEMICAL					
pH	5.9	7.4	7.4	8.1	8.9
EC (dS/m)	0.3	6.4	4.0	4.2	12.1
PO_4-P (mg/L)	2.0	1.3	1.1	86.3	45.6
TKN (% w/w)	0.3	2.0	1.0	1.5	2.2
NO_3-N (mg/kg)	5.5	355.3	447.0	78.0	19.8
NH_4-N (mg/kg)	1.2	14.0	9.5	61.7	1835.5
NH_4-N / NO_3-N (Ratio)	2.0	5.0	0.0	0.0	36.0
Fe (mg/kg)	4,734	8,896	11,300	3,645	5,285
C:N (Ratio)	161.0	10.9	12.0	15.0	12.2
CCE (% w/w)	2.8	16.4	-	5.0	9.1
BIOLOGICAL					
Seedling Emergence (%)	99.0	95	100.0	100	5
Seedling Vigor (%)	5.5	71.0	97.6	90.0	1.0
CO_2 Evolution (mg/gTS/d)	0.5	0.6	0.7	0.9	2.0
Salmonella (MPN/g dw basis)	0.0	0.0	5.8	3.1	1.5
T. Coliform Bacteria (MPN/g dw basis)	1,400	10.8	4.0	5.4	1.8

AD Product Data



AD Processes

- Technology/process will affect

- What you produce, and
- Necessary post digestion processes

- High vs. low solids digestion

Match feedstock to technology

Product Data - Solids

Characteristics	Units of Measure	Compost	Fiber
Total Nitrogen	% dry wt	2.2	1.4
Total Phosphorus (P_2O_5)	% dry wt	1.3	1.1
Total Potassium (K_2O)	% dry wt	3.0	1.6
Calcium (Ca)	% dry wt	2.1	2.3
pH Value	**Units**	**8.74**	**8.58**
Electrical Conductivity	**mmhos/cm**	**11.01**	**9.72**
Organic Matter	% dw	79	86.7
C/N Ratio	Ratio	**20**	**37**
Moisture	**%**	**66.1**	**69.2**
Stability	**mg CO_2-C/g OM/day**	**1.5**	**5.6**
Maturity - Emergence	%	100	N/A

Understand product – manure feedstock, low solids AD, little US data on biowaste

Different methods of processing

↑ Composting digester solids - aerobically

Processed and dried →

AD Liquid

- **Liquids**

  - Fertilizer – dilute or concentrate (?)

Still a lot of work to be done !

(nutrient value offset transportation cost?)

Product Data - Liquid

Nutrients	mg/kg	Other	
Total Nitrogen	6005	Percent Solids	5.8 %
Ammonia Nitrogen	**5825**	pH Value	8.09 units
Nitrate Nitrogen	125	**Electrical Conductivity**	**78 mmhos/cm**
Organic Nitrogen	55	**Respiration Rate**	**9643 mg CO2-C/L/day**
Total Phosphorus (P_2O_5)	1133	Organic Carbon	19069 mg/kg
Total Potassium (K_20)	4425	Humic Acid	2876 mg/L
Calcium (Ca)	1907	Turbidity	7640 NTU
Magnesium (Mg)	769	Suspended Solids (SS)	17000 mg/L

Understand product – manure feedstock

High Solids AD

Easy to compost post digestion

No water to deal with

High Solids AD Data*

Characteristic	Fresh Feedstock Blend (fresh mass)	After 28 days Digestion (fresh mass)
Total Solids (g/L)	42,428	36,344
K (mg/kg)	6,619	6,069
K_2O (mg/kg)	7,976	7,314
Mg (mg/kg)	2,414	2,551
P (mg/kg)	1,816	1,501
P_2O_5 (mg/kg)	4,158	3,437

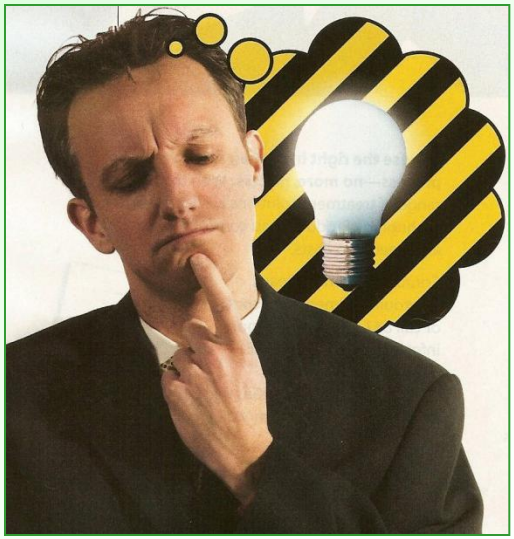
**Biowaste – food/green*

Small moisture content increase, nutrients concentrate, Carbon content decreases

Product Development
Through Blending / Characterization

- **What does the market want / need ?**

  Do the research, trials, testing



- **What can be produced?**

  Use testing to figure it out !

EXAMPLES

Blending Trials

Dangerous without proper characterization and research

Root Zone Guidelines vs. Blending Data

Characteristics	USGA Guidelines	STRI Golf Guidelines (UK only)	90 : 10 Sand: Compost	85 : 15 Sand: Compost	80 : 20 Sand: Compost
Saturated Hydraulic Conductivity	≥ 150 mm / hr	≥ 150 mm / hr	780	577	429
Total Porosity (%)	35 - 55 %	≥ 35 %	38.2	39.3	39.1
At 30 cm Tension					
Air-Filled Porosity (%)	15 - 30 %	≥14 %	16.6	17.5	12.5
Capillary Porosity (%)	15 - 25 %	≥17%	21.6	21.8	26
Bulk Density (g/cc)			1.6	1.57	1.54
Particle Density (g/cc)			2.59	2.58	2.53
Organic Matter Content (%)	1% - 5% (2-4% ideal)	0.5 - 3.5 %	1	1.3	1.4
At 40 cm Tension					
Air-Filled Porosity (%)	Not Applicable	Not Applicable	26.6	26.6	23.6
Capillary Porosity (%)	Not Applicable	Not Applicable	11.6	12.7	15.6
pH			6.6	6.5	6.3

Blended Topsoil Compost

Characteristics	Units of Measure	Sandy soil	1:2 Compost : Sand	1:1 Compost : Sand
Nutrients				
Carbon	%	2.51	3.9	4.86
Nitrogen	%	0.05	0.16	0.25
Phosphorus (P)	ppm	56	95	113
Potassium (K)	ppm	26	417	608
Calcium	ppm	441	849	1023
Magnesium	ppm	107	192	243
Zinc	ppm	47.1	43.5	40.4
Copper	ppm	3.6	3.4	3.2
Sulfur	ppm	31	51.5	53.1
Other Parameters				
Organic Matter	%, dry wt. basis	0.3	1.5	1.8
pH Value	Units	7.5	7.5	7.7
Electrical Conductivity	dS/m^2	0.1	0.34	0.43
CEC	meq/100g	3.2	6.9	8.7
Particle Size Analysis				
Sand	%	95.2	93.3	92.5
Silt	%	1.1	1.7	2.4
Clay	%	3.7	5	5.1
Textural Classification		Sand	Sand	Sand

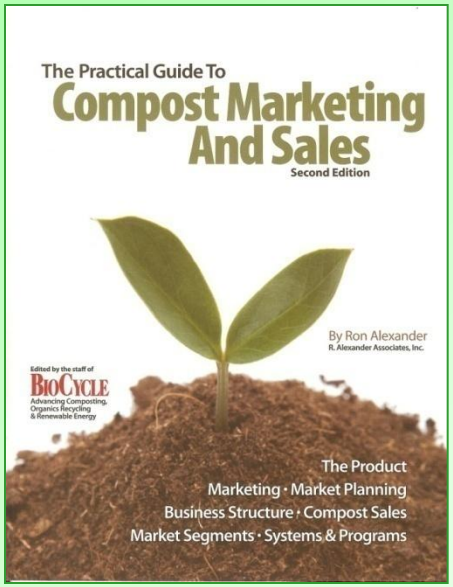
Test for parameters important to customers and application

Conclusions / Comments

- Industry has appropriate testing methods developed
- Characterization data is being collected for composts (needs to be analyzed, nationally)
  - Some composters are testing, effectively using the data (many collect data and *store* it)
- Little investment has been made into studying AD products in the U.S.
  - National funding available?
- Industry must take product development seriously

QUESTIONS ?

Available through Biocycle....



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