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Mechanically Enhanced Biodrying of Biosolids Using the Agitated Bay Composting System

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Challenges

- Changes in biosolids management practices and industry
- Woody amendment now a commodity
- Energy cost increases for traditional drying
- Outdoor drying issues (China)

Solution

- Controlled agitation and aeration
- Automated agitation
- Biodried biosolids recycled as amendment
- Enclosed facility avoids weather impact
- Biodrying saves energy compared to traditional drying
- IPS System has flexibility to biodry or compost

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Biosolids Management

Composting **Drying**

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Biodrying

Technology Comparison

Composting vs. Biodrying

Similarities

- Biological process
- Self generated heat
- Static/Mechanical
- ≥ 18 days
- Area depends on process

Differences

- Cellulose Amendment vs. Dried Biosolids
- Moisture Control

Drying vs. Biodrying

Similarities

- Stabilize /reduce moisture & volume
- Recycles dried biosolids
- Mechanical
- Produces fertilizer/fuel

Differences

- Thermal vs biological process
- Supplied vs self-generated heat
- 24 hours vs ≥ 18 days
- Retains calorific value
- Space requirments differ

Mechanically Enhanced Biodrying

Biodrying: Partially drying biological materials using self generated heat from microbial biochemical processes.

- Air drying as sun/humidity/ temperature impacts drying
- Subject to extreme weather
- Occasional manual turning
- Takes months to dry

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Mechanically Enhanced Biodrying

IPS Mechanically Enhanced Biodrying: Incorporates mechanical processes such as forced aeration and pile agitation to further expedite moisture evaporation.

- Increases microbial activity
- Self-generated heat
- Automated process control and turning
- Fully enclosed
- Days to dry

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Mechanically Enhanced Biodrying

- **Mr. Richard Nicoletti, P.E.**

  Pilot Study Project Manager

- **Mr. Lewis Naylor, PhD**

  Pilot Study Process Consultant and Evaluator

Personnel

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Mechanically Enhanced Biodrying

Anthony Dupont Compost Facility
Bristol, Rhode Island

July - August 2008
Phase I
Phase II

Summer Trial

Merrimack Composting Facility
Merrimack, New Hampshire

September 2009 – February 2010
Pre- Pilot Test
Pilot Test

Winter Trial

Study Locations – *Northeast USA*

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Study Goals

Warm weather trials, June- August 2008, Bristol, RI

- Test use of dried biosolids as single amendment
- Determine biodrying potential/time requirements
- Determine pathogen destruction capability
- Mechanical and biological limits of the IPS Technology

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Study Goals

Cold Weather Trials, September 2009 – February 2010, Merrimack, NH

- Test ability to achieve 65% solids at ambient temperatures < 0°C
- Assess production of adequate compost for recycle
- Confirm retention time in bay
- Evaluate pathogen destruction temperatures and PFRP temperatures
- Estimate heating value of product for fuel use
- Identify critical input/output parameters and boundary conditions

Goals

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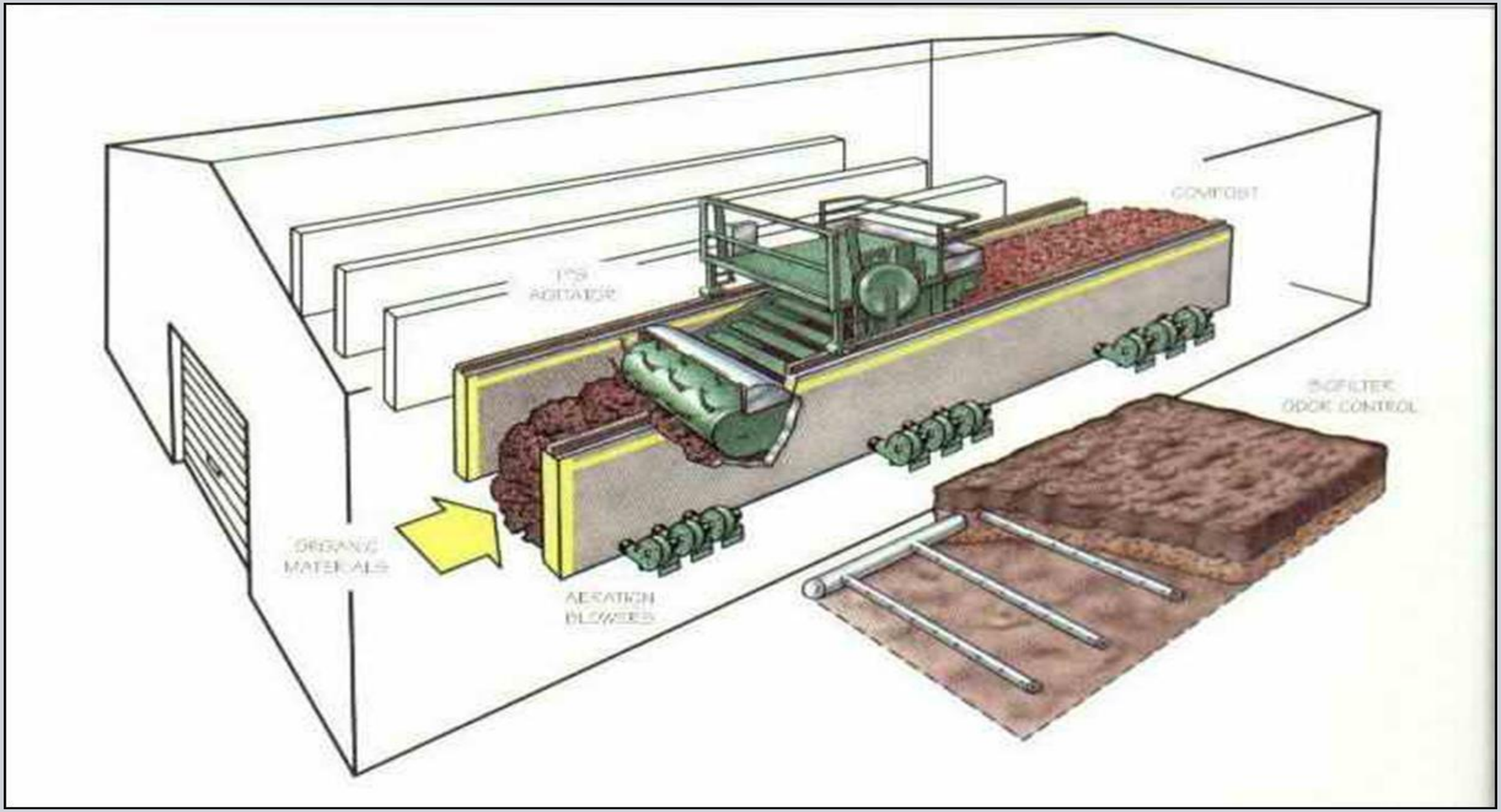
IPS System Overview

Agitated Bay, Forced Aeration Composting & Biodrying System



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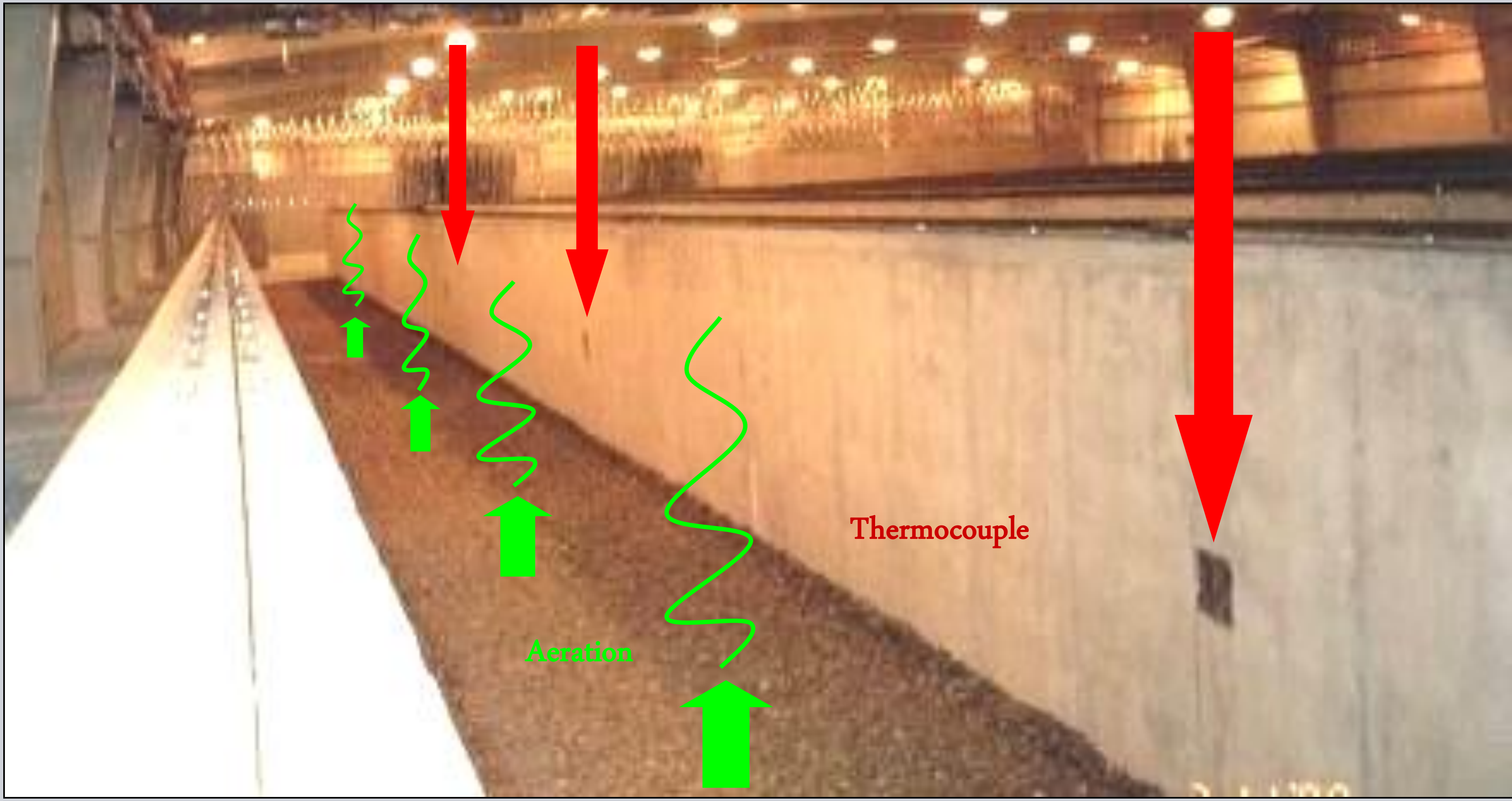
IPS System Overview



IPS Composting & Biodrying

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IPS System Overview

IPS Biodrying & Composting Process Animation

IPS Composting & Biodrying

IPS System Overview

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Facility Description

	Bristol	Merrimack
Facility Age:	15 years	15 years
No. Bays:	4	15
Materials Processed:	Primary/Secondary sludge with shredded green waste	Undigested/Digested sludge & septage w/ sawdust, shredded green waste
Sludge ds:	**Avg. 25%**	**10 – 25%**
Agitator Power:	**30 HP** (recent replacement)	**25 HP** (original)
Ambient Temp.:	**59°F to 100°F**	**8°F to 54°F**
Bay Dimensions:	220 ft long x 6 ft wide x 6 ft deep	
Blower Qty./Power:	5/3 HP	
Distance/Agitation:	12 feet	

Facility Data

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Bristol Pilot Study

Bristol Study

Phase I: Drying was primary objective

- Drying as quickly as possible
- 22% ds sludge blended with dried biosolids pellets (>90%ds)
- Optimize agitation & aeration (a & a) to achieve ≥65% ds finished product

Phase II: Achieving PFRP was primary objective

- 22% ds sludge blended with Recycle (85% ds)
- Optimize a & a to achieve PFRP (3 days @ 55°C) & VAR (14 days @ 45C)
- Achieve a >65% solids finished product (secondary)

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Strategies

Merrimack Study

Merrimack Study

Pre-Pilot Test: Generate dried biosolids for Pilot Test

- 4 Passes run to create a carbon-free amendment for Pilot Test
- Sludge avg. @ 19% DS blended with sawdust @ 85%ds
- Optimize a & a to achieve ≥65% ds finished product

Pilot Test: Achieve 65% ds dried biosolids from 45% ds Test Mix

- 4 Passes run to test variables (agitation frequency/mix variation/aeration)
- Optimize a & a to dry and achieve PFRP Temps.
- Sludge solids declined due to seasonal variations
- Mimic effect of longer bay length

Mechanically Enhanced Biodrying

RESULTS

Bristol Study

Phase I: Reached 65% ds after Day 9 & 88% ds after Day 24

Phase II: Achieved PFRP Temperatures, dried from 41% ds to 68% ds in 18 days

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Mechanically Enhanced Biodrying

RESULTS

Merrimack Study

Pre Pilot Test: Created carbon-free recycle for PT

Reached 65% ds after Day 24

Pilot Test: Low solids content of sludge had a negative cascading effect on the ability to achieve the desired Test Mix and Recycle solids content

Challenging results from trial defined the parameters required to achieve 65% solids content:

Results

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Mechanically Enhanced Biodrying

RESULTS

BOUNDARY CONDITIONS FOR BIOSOLIDS TO ACHIEVE BIODRYING

Sludge ≥ 20% DS, ≥ 60% VS

Input Mix ≥ 45% DS

Results

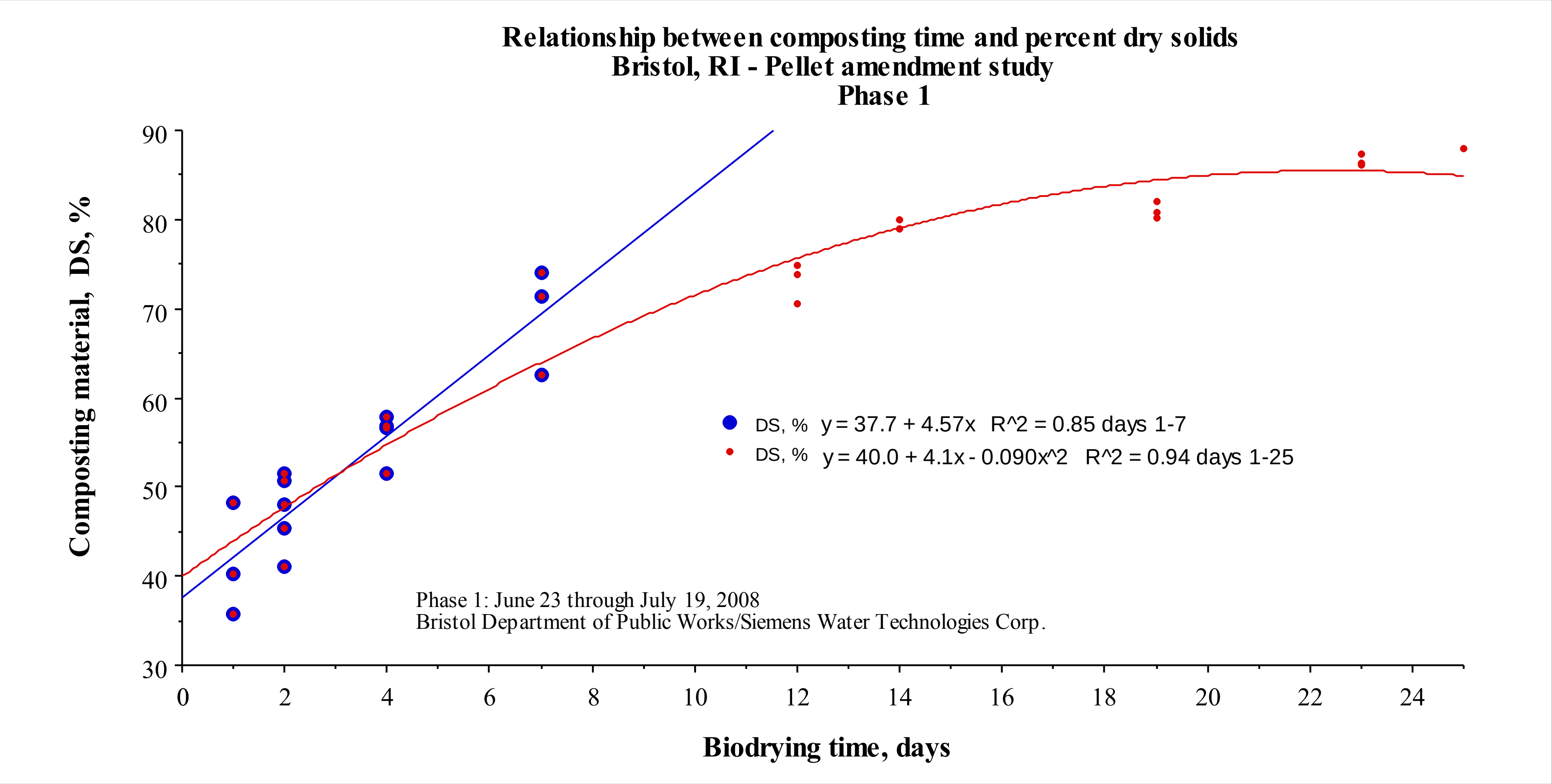
Summary of MEB Output Test Passes

Passes P4, 1, 2, 3 and 4

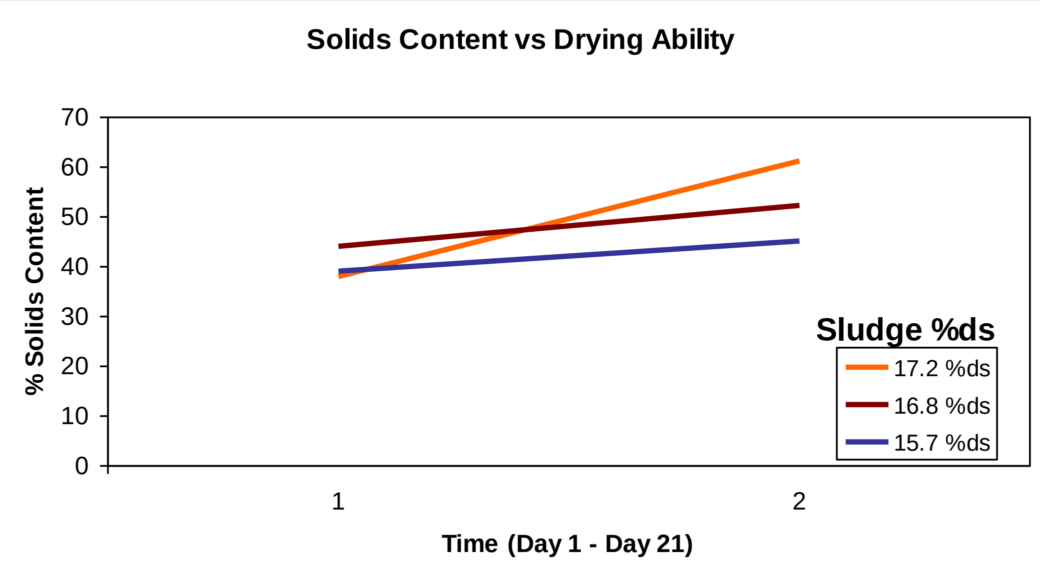
Duration Pass P4 thru 4:	**3 Nov – 26 Feb** ***(85 days)***
Average sludge dry solids:	**20% to 16%**
Average recycle dry solids:	**52% to 45%**
Average input mix dry solids:	**42% to 37%**
Average output dry solids:	**55% to 47%**

Ambient Temperature: **8°F to 54°F**

Solids Content vs Biodrying Time (Bristol)



Solids/Energy Content vs Drying Ability



Solids Content of Sludge & Recycle vs Drying Ability

Charge Date	Sludge (% ds)	Recycle (% ds)	Infeed (% ds)	Discharge (% ds)	Solids Increase (% pts)	Retention Time (days)
21-Dec	**17.2**	**60**	**38**	**61**	**23**	**21**
29-Dec	**16.8**	**50**	**44**	**52**	**8**	**21**
5-Jan	**15.7**	**48**	**39**	**45**	**6**	**21**

Temperature vs. Time (Bristol)

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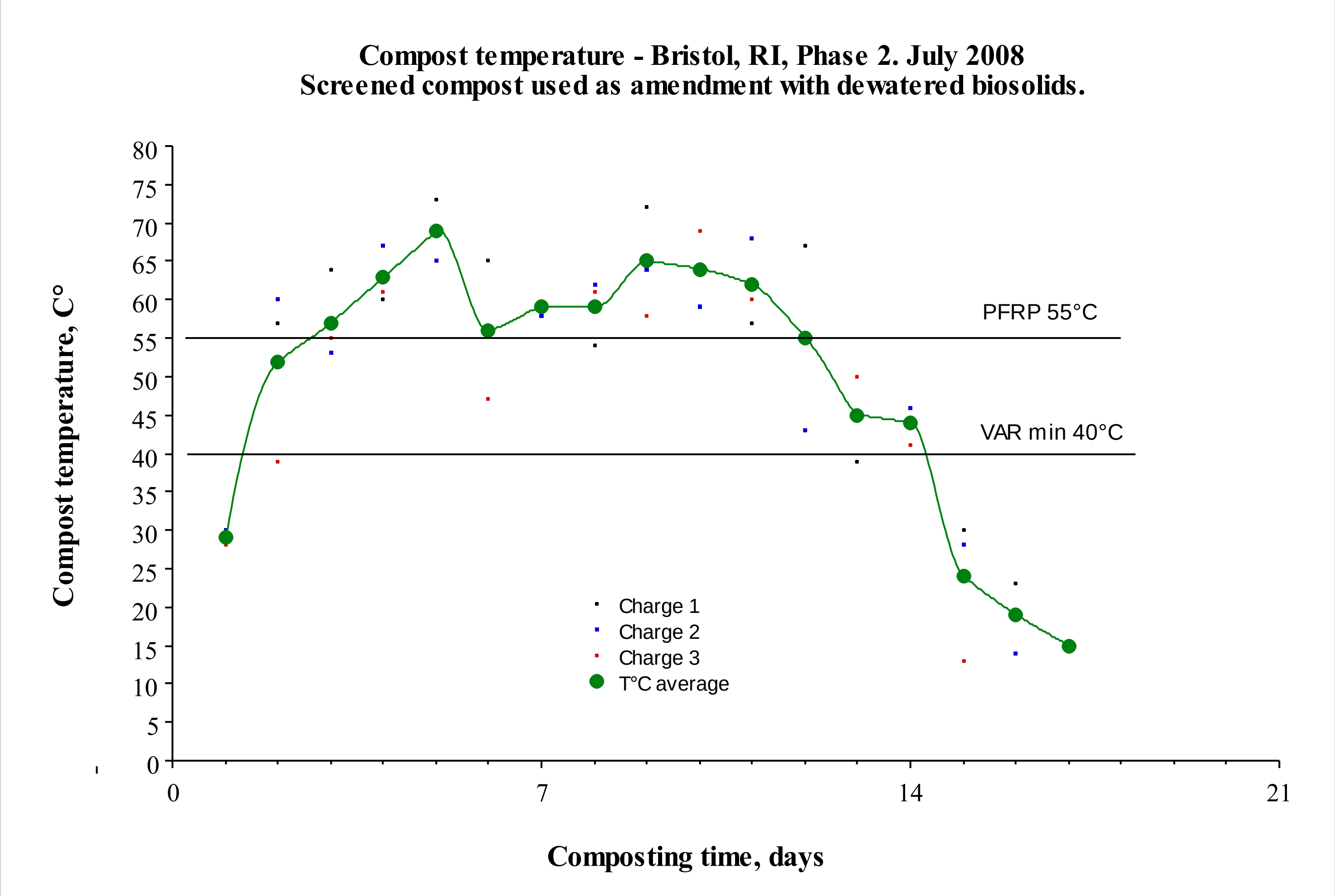
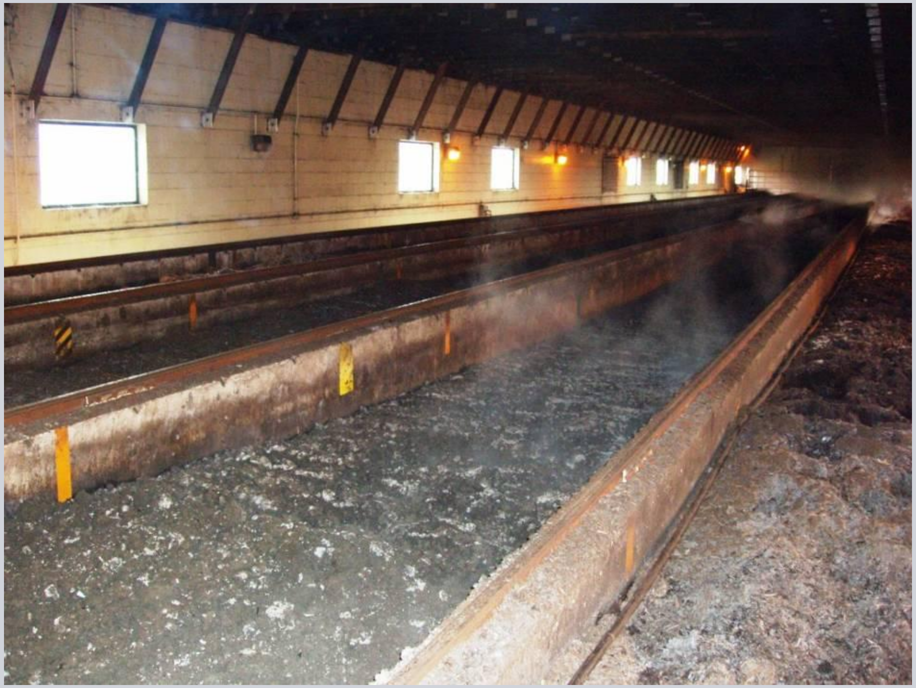


Bay Volume Reduction

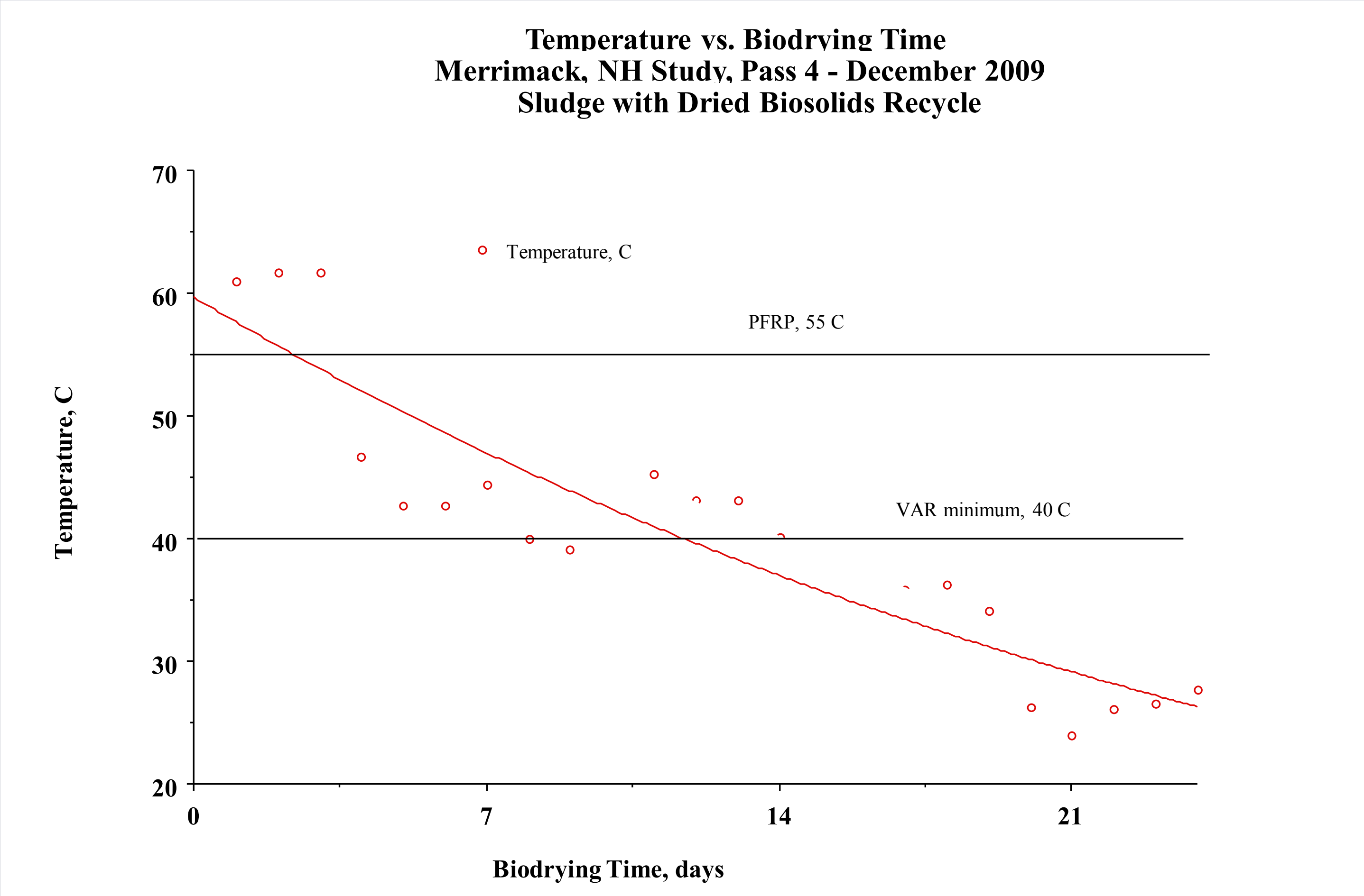
Volume reduction in the bay ≈ 20%



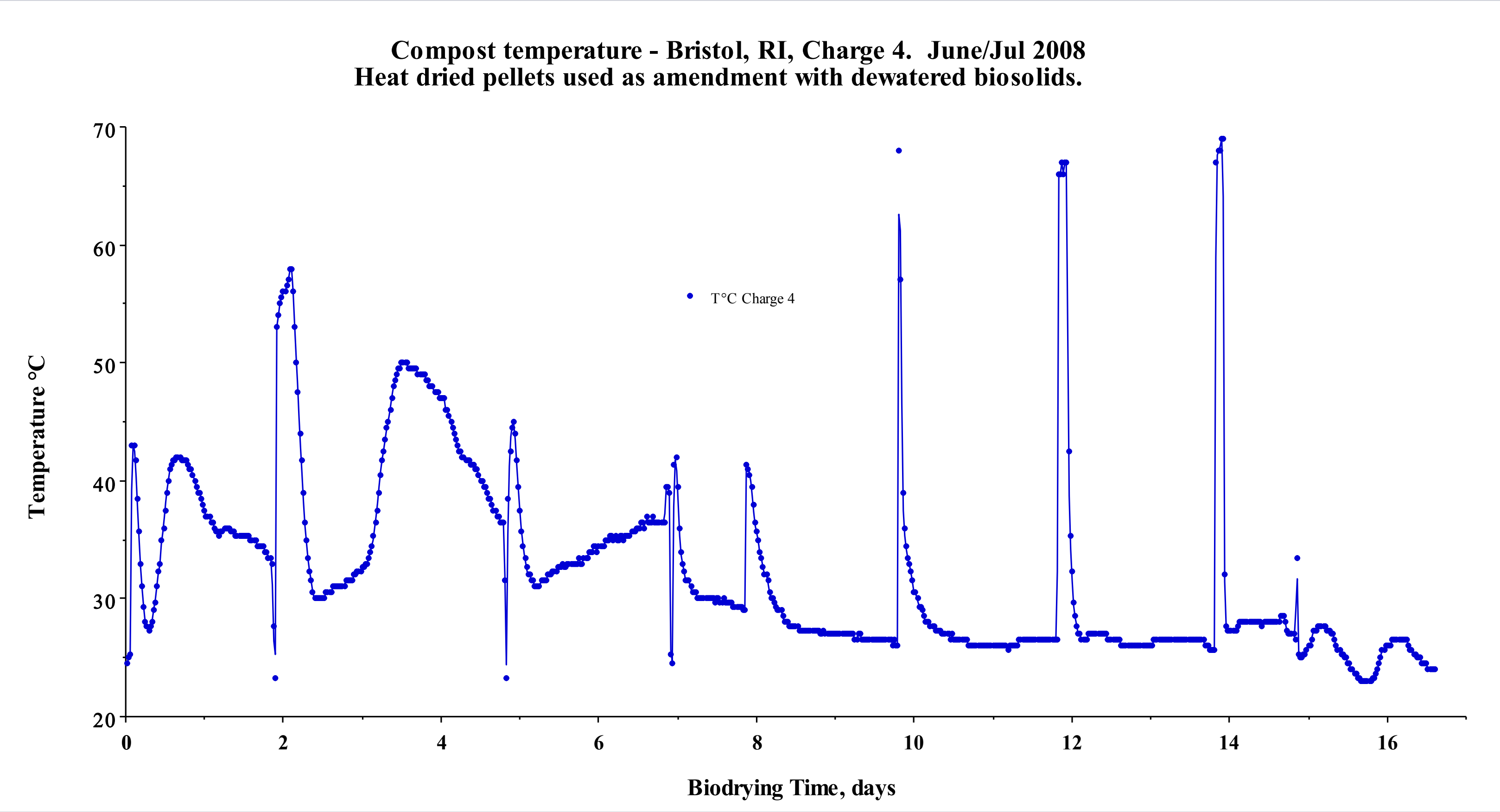
Bristol Volume Reduction

Merrimack Volume Reduction

Temperature vs. Time (Merrimack)



Temperature Vs Time with Agitation



Pilot Study Variables

Uncontrollable Variables:

- **Sludge Solids Content** *(≥ 20% required)*
- **Physical/Chemical Properties of the Sludge**
- **In Bay Volume Reduction** *(affects recycle quantity)*
- **Charge Densities/Stickiness** *(affects process ability and capacity)*
- **Ambient Air Temperature and Humidity**

Pilot Study Variables

Controllable Variables:

- **Recycle** *(minimum 65% solids)*
- **Bay charge size** *(maximize for heat retention & recycle quantity)*
- **Test mix composition** *(45% min & biodegradable VS)*
- **Aeration rates and scheme** *(optimize for drying first, then PFRP)*
- **Agitator frequency** *(once daily)*
- **Ventilation rates** *(min. to remove moisture from building ≥ 8 ACPH)*

Energy Consumption

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15 year old 25 HP Agitator

Agitator Power to Area Ratio Summary

Agitator Motor Power (HP)	Agitator Motor Power (KW)	Area Cross Secion (m2)	Power:Area Ratio (KW/m2)
25	18.5	3.7	5.0
30	22.5	3.7	6.1
50	37.5	4.6	8.1
100	74.5	7.0	10.6

New 100 HP Agitator

Energy Consumption

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Energy Consumption per Unit of Test Mix

	Power Consumption per Volume of Test Mix	Power Consumption per Weight of Test Mix
Bristol - Fuel	0.4 liters/m3	0.8 liters/tonne
Bristol - Electricity Phase I	1.8 KWH/m3	3.4 KWH/tonne
Bristol - Electricity Phase II	2.9 KWH/m3	5.9 KWH/tonne
Merrimack - Electricity	8 KWH/m3	15 KWH/tonne

Assumes average density of test mix at 0.53 tonnes/m^3

Merrimack – agitator used 1 hour per day, assumed full draw traveling the length of the bay blowers ran 3 hours/day

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Heat Value Calculation

Estimated Heat Value of Biodried Biosolids

Using Haug's equation for compost, for this application only the Volatile Solids (VS) have energy

	Volatile Solids % of Dry Solids	Heat Value Dry VS (kJ/kg)	Heat Value Dry Bulk Solids (kJ/kg)	Dry Solids Solids Content (%)	Moisture Content (%)	Adjusted Heat Value for Moisture (kJ/kg)	Adjusted Heat Value for Moisture (kcal/kg)	Notes
Wet Wood	-	19,800	-	50	50	12,300	2,910	
Typical Compost	87	23,260	20,240	55	45	13,060	3,090	
Merrimack MEB Output	62	23,260	14,420	48	52	8,780	2,080	(Lowest Average Recorded)
Expected MEB Output	62	23,260	14,420	65	35	10,150	2,400	(20% Sludge/45% Test Mix)
Bristol MEB Output	79	23,260	18,380	68	32	13,290	3,140	(Pass II/Charge II)
Estimated MEB AVG	**60**	**23,260**	**13,960**	**65**	**35**	**9,820**	2,320	(Based on China samples)
		kcal/kg	kcal/kg					
		5,500	**3,301**					

Sources: [d] Equation from *Textbook of Wood Technology* - Panshin, A.J. and C. deZeeuw. 1980.

[e] 23,260 kJ/kg (10,000 BTU/lb) from *The Practical Handbook of Compost Engineering* - Haug, Roger, 1993

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Mechanically Enhanced Biodrying (MEB)

- Mechanically Enhanced Biodrying relies on biological & mechanical processes
- Biodried biosolids can be used successfully as amendment
- Key process boundary conditions to achieve 60% DS in product:

  Sludge 20% ds at 60% VS and Infeed Mixture at 45% ds

- IPS MEB process effectiveness declines with solids contents lower than above.

Conclusions

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Mechanically Enhanced Biodrying (MEB)

- Sludge characteristics determine time requirements to biodry and meet PFRP. 20 days will achieve a typical 20 percentage point increase in dry solids
- IPS equipment performed well and not impacted by higher density materials.
- Bay volume reduction of about 20% (sufficient volume to meet process needs and provide surplus for fuel/fertilizer)
- Sufficient time & energy available in MEB process to achieve pathogen destruction if parameters are met

Conclusions

Mechanically Enhanced Biodrying (MEB)

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- Low temperatures should not impede process if parameters are met
- Higher Heat Value of finished product estimated at 8,500 kJ/kg ≈ 50% wet wood

Conclusions

Acknowledgements

Thank You!

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