Biogas Production from Municipal Organic Solid Wastes

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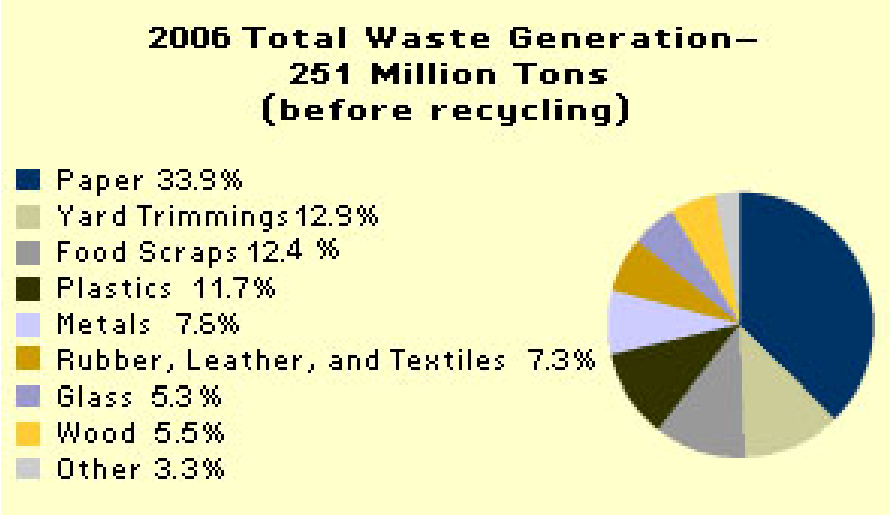
Municipal Solid Waste (MSW) Generation and Management in United States

- **Amount**
  - 250 million tons per year
    - 32% recycled
    - 68% landfilled
- **Composition**
  - 65% Biodegradable (paper, yard trimmings, food scraps, wood)
  - 35% Non-biodegradable (plastic, metals, rubber, glass, etc.)



US EPA

Separation of Biodegradable Materials from MSW

- Source separation before collection
- Separation after collection
  - Mechanical separation by density and size
  - Thermal or biological treatment combined with mechanical separation
    - Thermal treatment – heating and steam explosion
    - Biological treatment – rotating drum reactor (RDR) (commercial names: Bedminster, Biomixer)

Organics

Raw MSW

Inorganics

Operating Conditions of RDR Process

- ✓ **Batch or continuous with daily feeding**
- ✓ **Desirable Moisture Content of Feed: 50-60%**
- ✓ **Temperature in Drum: 50-55°C**
- ✓ **Retention Time: 6 hours to 5 days**
- ✓ **Aeration Using Air-Blowers**

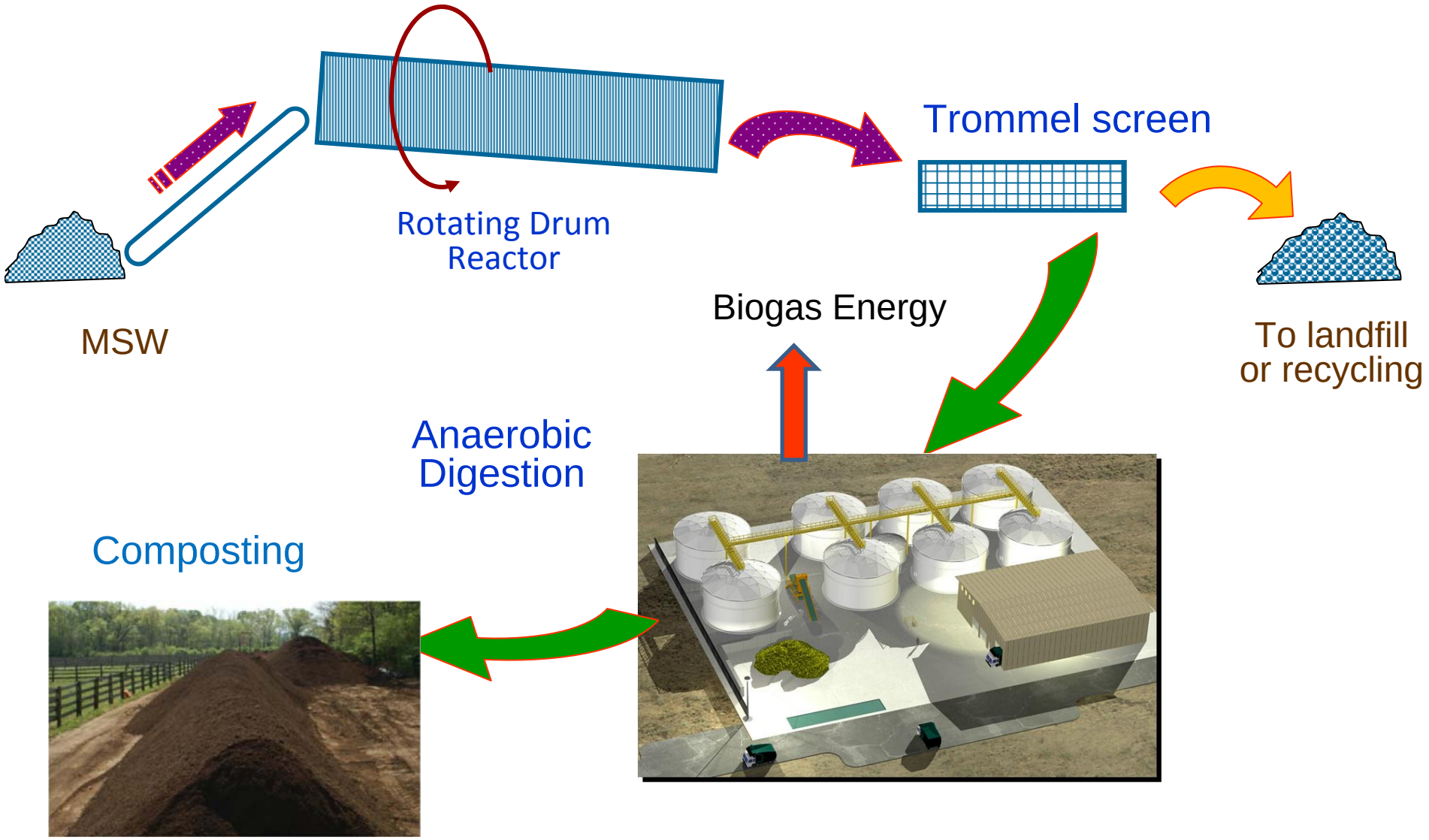
MSW TREATMENT PLANTS USING RDR

LOCATION	OPENED	NO. OF DRUMS	PLANT CAPACITY t/d
Big Sandy, TX	1971	1	30
Pinetop-Lakeside, AZ	1991	1	75
Sevierville, TN	1992	5	350
Sorel-Tracy, QC, Canada	1992	1	100
Cobb Country, GA	1996	5	350
Rapid City, SD	1996	2	220
Sumter County, FL	1997	1	75
Marlborough, MA	1999	2	150
Nantucket, MA	1999	1	100
Port Stephens, NSW, Austr.	1999	2	120
Edmonton, AL, Canada	2000	5	750
Saitama, Japan	2001	1	60
Hines, AK	2002	1	30
Cairns, Queensland, Austr.	2002	4	300
Perth, WA, Australia	2003	4	350
Delaware County, NY	2005	1	100

Research Goal

- ✓ Develop an integrated treatment system that can effectively separate the organics from MSW and convert it into biogas energy and compost.

Integrated RDR-APS-Digester System



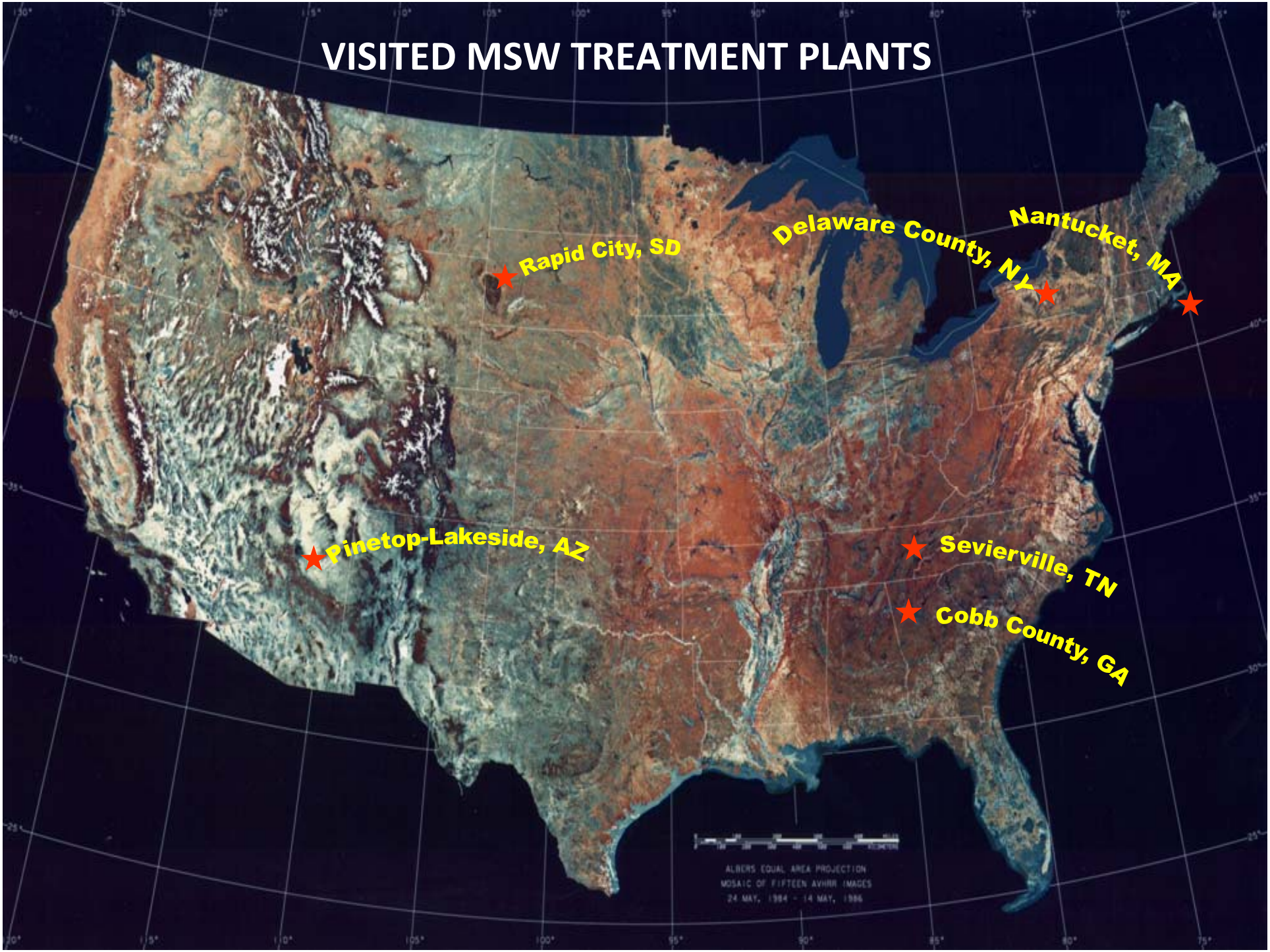
Research Objectives

- ✓ Characterize the organic materials derived from MSW via Rotating Drum Reactor process
- ✓ Determine the biogas production potential of the organic materials and analyze the feasibility for use as feedstock for anaerobic digestion.

Research Approach

- Survey six facilities in US that use RDR process for treating municipal solid waste
  - MSW types and amount
  - RDR specifications and operating conditions
- Sample and analyze the organic materials produced from the RDR for physical and chemical characteristics
  - Bulk density, moisture content, solids content, and nutrient and metal contents
- Perform batch anaerobic digestion tests to determine the rate of digestion and biogas and methane yields of organic samples.

VISITED MSW TREATMENT PLANTS



PARAMETER	AZ	MA	NY	SD	TN	GA
Type of waste	MSW Biosolids (BS) Paper & cardboard	MSW Biosolids Yard waste	MSW Biosolids	MSW Biosolids	MSW Biosolids	MSW Biosolids
Capacity (ton/d)	20MSW+10 BS 10 P&C +10 BS	20-100 MSW 7.5 BS and YW	100 MSW 30 BS (16% TS)	220 MSW 9 BS (8% TS)	225 MSW 55 BS (18% TS)	200 MSW 60 BS (20% TS)
Organics recovered (% of MSW)	55	80	55-60	52	60	65
Moisture content in drum (%)	55-60	55	50-55	55	55	55
Max Temperature in drum (°C)	44	52-58	35	13-20	46-52	55
Retention in drum (d)	3	3	3-5	0.25	3	2
Number of drums	1	1	1	1	5	5
Rotation speed (rpm)	1	1	1	5	0.83	1
Aeration in drum	Yes	No	Yes	Yes	Yes	Yes
Openings, primary screening (mm)	31.8	25.4	31.8	44.5	38.1	31.8


COBB COUNTY


DELAWARE


SEVIERVILLE


RAPID CITY


PINETOP-LAKESIDE


NANTUCKET

Characteristics of Organics Recovered from MSW via RDR Process

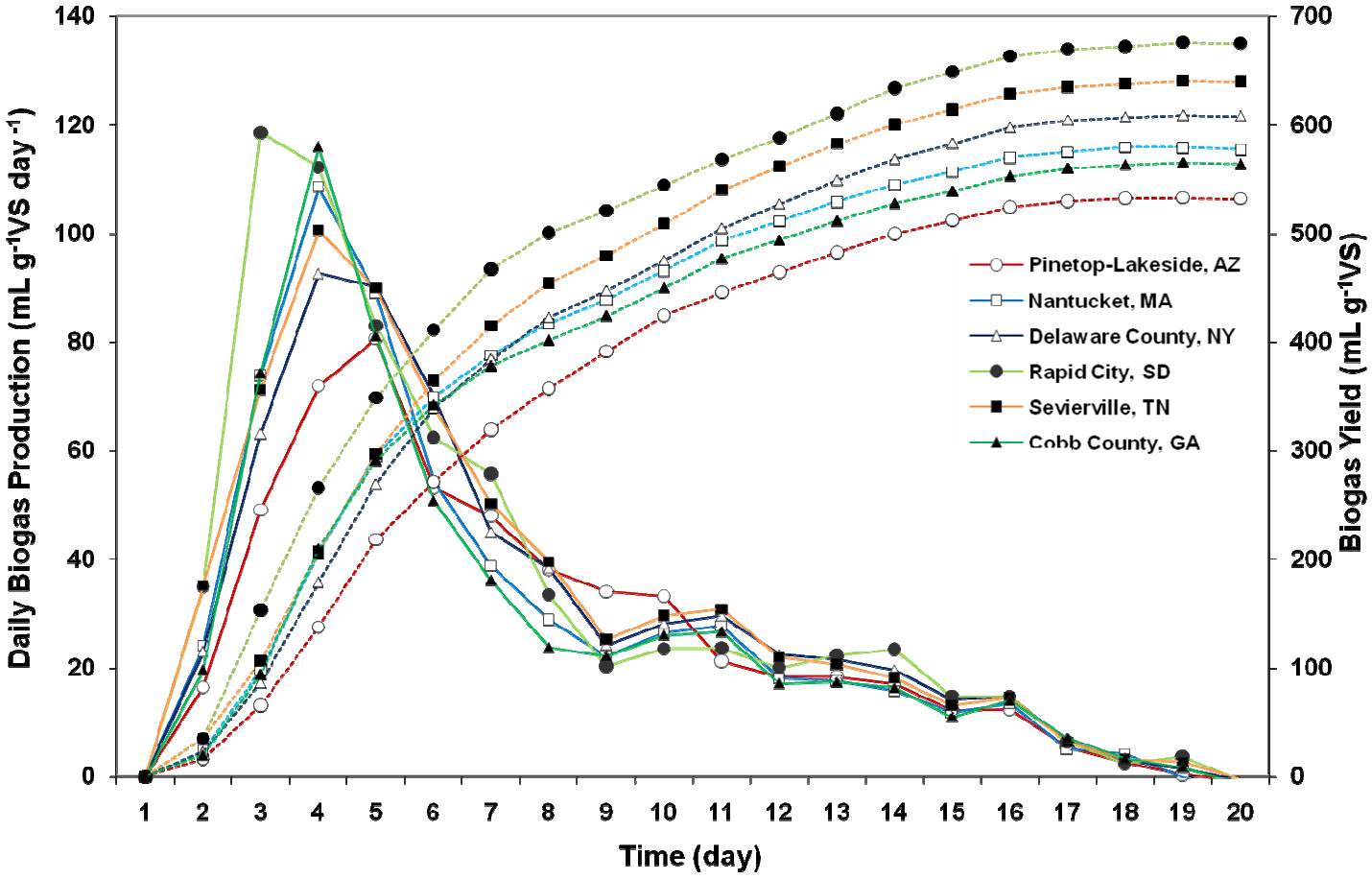
RDR Facility		TS (%)	MC (%)	VS (%)	VS/TS	C (%)	N (%)	C/N
AZ	Average	49.38	50.62	34.79	0.706	35.33	1.44	24.51
	St. dev.	3.82	3.82	2.30	0.041	3.01	0.08	2.24
MA	Average	55.61	44.39	41.28	0.743	37.57	0.92	40.87
	St. dev.	2.38	2.38	2.40	0.025	3.20	0.08	2.18
NY	Average	43.85	56.14	32.67	0.745	37.30	1.03	36.46
	St. dev.	3.93	3.93	3.15	0.021	1.97	0.11	2.03
SD	Average	47.75	52.25	34.79	0.735	37.07	0.88	42.74
	St. dev.	7.59	7.59	2.87	0.058	0.60	0.13	7.72
TN	Average	47.67	52.33	38.59	0.811	39.53	1.08	36.88
	St. dev.	4.52	4.52	3.32	0.026	2.18	0.12	2.34
GA	Average	35.24	64.76	26.97	0.766	38.47	1.09	35.37
	St. dev.	5.36	5.36	4.22	0.033	1.62	0.07	2.58

TS-total solids, MC-moisture content, VS-volatile solids, C-carbon, N-Nitrogen

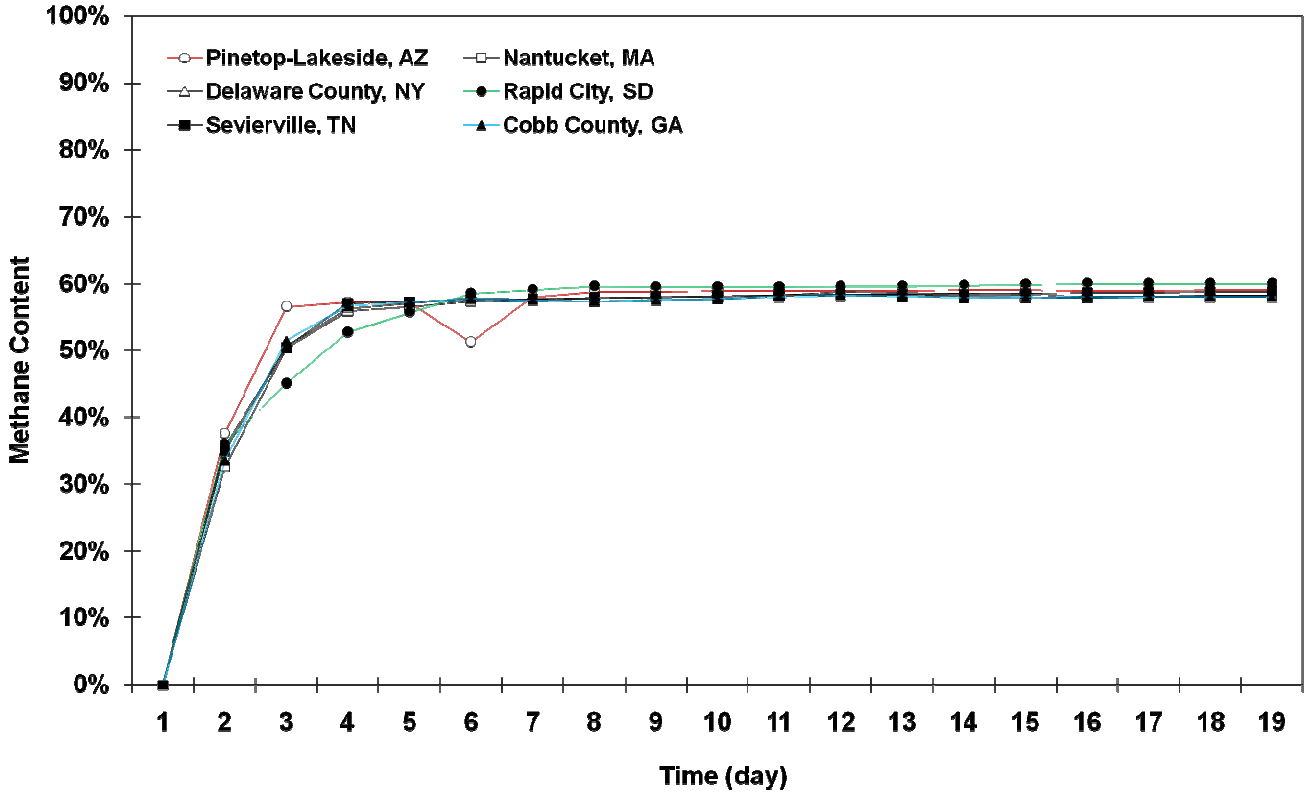
Batch Anaerobic Digestion Tests

- Anaerobic Reactors
  - 0.5 L working volume and 1.0 L total volume
- Inoculum
  - Thermophilic Anaerobic Sludge from a working digester
- Test Conditions
  - Initial volatile solids loading: 3 gVS/L
  - Temperature: 55+2°C
  - Digestion time: 20 days
- Measurements and Results
  - Daily biogas yield (ml/gVS.day) and cumulative biogas yield (ml/gVS)
  - Biogas composition (% methane and carbon dioxide)
  - Initial and final pH in the reactor

Dairy Biogas Production and Biogas Yield During Batch Thermophilic Digestion



Methane Content of Biogas Produced During Batch Anaerobic Digestion



Biogas Yields of Organics Recovered from MSW via RDR Process

RDR Facility		Biogas Yield (ml/gVS) 13 d	20 d	Methane Content of Biogas (%)
AZ	Average	483	533	59
	St. dev.	34	37	
MA	Average	529	579	58
	St. dev.	13	16	
NY	Average	549	609	58
	St. dev.	30	26	
SD	Average	611	676	60
	St. dev.	36	35	
TN	Average	583	641	59
	St. dev.	36	44	
GA	Average	512	565	58
	St. dev.	9	12	

Conclusions

- The organic materials recovered from MSW using the RDR process have 44-60% moisture content, high organic content, 70-89% volatile solids in total solids, and 22-40 C/N.

- They are highly digestible with relatively high biogas yields, 533 -676 ml/gVS or 0.533-0.676 m^3/kgVS. The biogas contained 58-60% methane.

- The organic materials derived from RDR process are suitable feedstock for anaerobic digesters.

Pilot Testing Planned for Anaerobic Digestion of Municipal Organic Solids Wastes at UC Davis

Acknowledgement

- Funding support from California Integrated Waste Management Board
- Cooperation of six MSW treatment plants