NREL/TP-431-4988I • UC Category 249 • [redacted]

Data Summary of Municipal Solid Waste Management Alternatives

Volume IX: Appendix G—Composting

NREL/TP--431-4988I

DE93 008308

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A Division of Midwest Research Institute
Operated for the U.S. Department of Energy
under Contract No. DE-AC02-83CH10093

Prepared under subcontract no: RF-1-1103

October 1992

MASTER

Report Organization

This report, *Data Summary of Municipal Solid Waste Management Alternatives*, comprises 12 separately bound volumes. Volume I contains the report text. Volume II contains supporting exhibits. Volumes III through X are appendices, each addressing a specific MSW management technology. Volumes XI and XII contain project bibliographies. The document control page at the back of this volume contains contacts for obtaining copies of the other volumes.

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G.1 INTRODUCTION/OVERVIEW

Composting of municipal solid waste (MSW) is experiencing a dramatic resurgence in the U.S. (183, 151, 314, 213, 742, 667). Several factors are driving this interest in composting including landfill closures, resistance to siting of new landfills and combustion facilities, public support for recycling, and, in general, the overall costs of waste disposal.

Starting with only one demonstration project operating in 1980, the total number of projects in the U.S. has increased from four in 1987 to sixteen by July 1991 (152, 757, 207, 206). Although one of the sixteen plants closed in early 1991, three more are in start-up, and ten are under construction. In addition, there are approximately 100 projects in some form of planning or development. One reason some communities are selecting composting as a waste management option is that sewage sludge and MSW can be co-composted thereby recycling a major portion of the overall municipal waste stream. In 1991, five of the operating facilities have incorporated sludge, with a number of new plants also developing systems with this capability.

The information provided herein is based largely on composting project data published in the open literature, combined with personal follow-up with selected plant operators. Generic composting technologies are briefly described in Section G.2, followed by a comprehensive discussion of operating facilities. Information is presented on the type of processing system, capital and operating costs, and the status of compost markets. A discussion is also included on the operational problems and challenges faced by composting facility developers and operators. Also presented are facility energy usage and a discussion of the energy implications from the use of compost as a soil and fertilizer replacement.

Capital and operating costs of U.S. facilities are compared and region-specific variables which impact total costs are presented. Tipping fees charged at each facility are contrasted. A discussion of cost sensitivity shows how facility costs are impacted by waste handling procedures, regulations, reject disposal, and finance charges.

The status of, and potential for, integrating composting into the overall waste management strategy is also discussed, including composting's contribution to municipal recycling goals, and the status of public acceptance of the technology. Finally, information and research needs are summarized.

G.2 TECHNOLOGY DESCRIPTION

The Ontario Ministry of the Environment (OME) released a report in 1990 entitled Composting - A Literature Study (743). Prepared by M.M. Dillon Ltd. and Cal Recovery Systems Inc, this report provides an excellent description of generic types of composting technologies and vendor MSW composting systems. Much of the following data are summarized from the OME report. Compost technologies and projects are also described in a number of other reports, referenced as appropriate throughout this text.

G.2.1 Generic Composting Technologies

Most MSW composting systems involve four distinct stages: collection, preprocessing, composting, and post processing (737, 388). Although all four steps are interrelated, the focus here is on the composting stage.

G.2.1.1 Turned Windrow

A variety of manual and machine techniques can be utilized to periodically mix compost piles so that most particles of waste materials are afforded sufficient oxygen to support aerobic biological activity such that the proper temperature is maintained in the central portion of the pile. The turning frequency is determined largely by pile temperatures. Specific minimum and maximum temperature limits indicate the need for turning to maintain optimal composting conditions and rates. The pile size can vary considerably depending on the amount of land area available, the type of material being composted, and the method of turning. Minimal pile height should be about 5 feet, with maximum heights about 10 feet depending on equipment capability. Most MSW composting facilities in the U.S. utilize the turned windrow method at some point in their operation.

G.2.1.2 Static Pile with Forced Aeration

Construction of a stationary compost pile on top of pipes or hollow blocks through which air is forced or drawn is commonly used for sludge composting and in a few MSW composting systems. Sometimes the static piles are disassembled and reconstructed to mix the piles. The static pile approach is not as suitable for mixed MSW due to its heterogeneous nature. Uneven air flow through the pile (channeling) can result, causing anaerobic conditions in the areas not receiving sufficient air flow.

G.2.1.3 In-Vessel

A consistent definition of in-vessel composting has not been established by the industry or the regulatory agencies. It is sometimes broadly interpreted as composting that takes place in a container of some sort where the material to be composted is aerated and mixed by mechanical means. The OME report classifies vessels used in this type of composting process as either rotating drums or tanks.

The mixing and tumbling of MSW inside a rotating horizontal drum provides particle size reduction and mixing of air and moisture. The drums are similar to a cement kiln in design and are as long as 180 feet with a diameter of up to 12 feet, although much smaller drums are also used. Some rotating drums retain the material inside for about 8 hours, functioning more as a pulping device than a composter since the materials must then be composted by one of the other methods. Some drums retain the waste for several days or weeks and actually function to digest the material, requiring less time in subsequent composting steps. Due to higher capital and operating costs, in-vessel systems are most commonly used with large volumes of MSW and sewage sludge.

Another type of composting vessel is configured with either horizontal or vertical tanks using forced aeration and mechanical agitation for composting sewage sludge and/or MSW.

G.2.1.4 Hybrid

As noted above, most in-vessel systems are followed by a static pile or windrow composting stage since production of stable compost requires more time than is economically feasible in the vessels.

G.2.1.5 Compost System Vendors

The OME report categorizes compost system vendors by the type of compost system used, although some of the listed companies only have experience with sewage sludge; and some do not have any operating facilities. Further, a number of the operating composting systems in the U.S. are custom designed. Compost system vendors are listed below according to generic technology type:

- Turned Windrow
    - Agripost
    - Ecological Technologies, Inc.
    - Environmental Recovery Systems
    - Compost Management Associates

- Static Pile
  - Buhler-Miag
  - Daneco
  - WPF Corporation

- In-Vessel
  - American Bio Tech
  - American Recovery Corporation
  - Ashbrook-Simon-Hartley
  - Bedminster Bioconversion Corp. (Eweson)
  - Compost Systems Company (Paygro, Dynatherm)
  - Ebara Environmental Corporation
  - Fairfield Service Company
  - International Process Systems
  - OTVD Group Energies
  - PURAC Engineering
  - Recomp
  - Royer Industries
  - Taulman Composting Systems

- Hybrid
  - California Co-Composting Systems
  - Harbert/Iriya International
  - Waste Processing Corporation (Dano)

BioCycle, Journal of Waste Recycling (154) publishes an annual listing of compost system vendors which include companies other than those listed by OME. Two other references which discuss vendor systems are Resource Recycling (213) and Waste Age (246).

G.2.2 Specific Facility Descriptions

Table G-1 provides an overview of key design and operating parameters for 16 MSW composting facilities in the United States as of July 1991. This information was compiled from many references, as noted under each facility profile in the table.

TABLE G-1. MSW COMPOSTING FACILITIES IN THE U.S. (as of July 1991)

PARAMETER	DELAWARE RECLAMATION PROJECT FACILITY #1	PORTAGE, WISCONSIN CO-COMPOSTING FACILITY FACILITY #2	RECOMP, INC. COMPOSTING FACILITY FACILITY #3	FILLMORE COUNTY COMPOSTING FACILITY FACILITY #4	SUMTER COUNTY COMPOSTING FACILITY FACILITY #5	PENNINGTON COUNTY COMPOSTING FACILITY FACILITY #6
LOCATION	WILMINGTON, DE	PORTAGE, WI	ST. CLOUD, MN	PRESTON, MN	SUMTERVILLE, FL	THIEF RIVER FALLS, MN
OWNER	DE SOLID WASTE AUTHORITY	CITY OF PORTAGE	RECOMP, INC. AND OTHERS (3-1)	FILLMORE COUNTY	SUMTER COUNTY	PENNINGTON COUNTY
OPERATOR	RAYTHEON SERVICE COMPANY	CASE BROTHERS	RECOMP, INC.	FILLMORE COUNTY	AMERICAN RECYCLING COMPANY	FUTURE FUELS, INC.
START DATE	1984	1986	1988	1987	1988	1985
COMPOST FEEDSTOCK	MSW+W.W. SLUDGE	MSW & W.W. SLUDGE	MSW (3-2)	MSW	MSW	MSW
DESIGN CAPACITY (T/D)	1000 MSW; 350 SLUDGE	16 MSW (2-1)	100 (3-3)	18 MSW	50	60
TIPPING FEE ($/T)	45 (1-1)	THROUGH TAXES	76	70 (4-1)	50	45
CAPITAL COST ($)	43,927,000 (1-2)	1,000,000	7 - 8 MILLION (3-4)	702,326	5 MILLION	1.3 MILLION (6-1)
OPERATING COSTS ($/YEAR)	8,322,526 (1-3)	100,000 (2-2)	1,000,000 (3-5)	278,795 (1989)	500,000	N/A
AMT. OF COMPOST PRODUCED (TPY)	37,000	2,200 EST.	N/A	1,179 (1988)	N/A	N/A
AMT. OF COMPOST MARKETED (TPY)	500	NONE	3,500 T BY 1990	3 - 4,000 BY 12/90	80 (FALL OF 1990)	8,000 BY FALL '90
PRICED REC. FOR COMPOST ($/CY)	4.50	NONE	4 - 8 (3-6)	NO CHARGE	NO CHARGE	NONE
COMPOST METHOD	FAIRFIELD DIGESTER	DIGESTER-TURNED PILE	DIGESTER/T. WNDR.	WINDROW	WINDROWS	WINDROW TURNING
REJECT DISPOSAL COSTS ($/T)	45	NONE - CITY LANDFILL	76	35 (1990)	50	12
POPULATION SERVED	450,000	8,500	48,000	20,000	30,000	15,000
WEIGH WASTE	YES	YES	YES	YES	YES	YES
SHRED WASTE	YES	NO	NO	YES	YES	YES
TURNING METHOD	N/A	FRONT-END LOADER	FRONT-END LOADER	FRONT END LOADER	WINDROW TURN. MACH.	WINDROW
HOUSEHOLD HAZ. WASTE DIVERSION	NO	NO	YES	STARTING 1990	NO	NO
SOURCE SEPARATED WASTE	NO	YES (RECYCLING PROG.)	NO	YES	NO	NO
MAJOR OPERATIONAL PROBLEMS	ODOR AND POOR MARKETS FOR COMPOST	NONE (2-3)	ODORS	COMPOST TOO MOIST TO SCREEN	COMPOSTING PAD AND MACHINE UNDERSIZED	LOW EFFICIENCY
REFERENCES	52,152,154,206,207, 213,314,752,741,738, 743,737,750	52,152,206,207,213, 314,741,738,743,737, 750	52,128,152,154,206, 207,213,324,752,741, 733,738,743,737,750	52,152,206,207,213, 314,752,733,738,743, 737,734,750	152,154,206,207,213, 246,314,752,741,738, 743,737	206,207,741,733,738, 737,750,758

TABLE G-1. MSW COMPOSTING FACILITIES IN THE U.S. (Cont)

PARAMETER	LAKE OF THE WOODS COUNTY COMPOSTING FACILITY FACILITY #7	SWIFT COUNTY COMPOSTING FACILITY FACILITY #8	AGRIPOST, INC. COMPOSTING FACILILTY FACILITY #9	BEDMINSTER BIOCON-VERSION CORP. CO-COMPOSTING FACILITY FACILITY #10	RESOURCE RECOVERY INC. FACILITY #11	BERRIEN COUNTY RESOURCE RECOVERY AUTHORITY FACILITY #12
LOCATION	GRACETON, MN	BENSON, MN	DADE COUNTY, FL	BIG SANDY, TX	COFFEYVILLE, KS	NASHVILLE, GA
OWNER	LAKE OF THE WOODS	SWIFT COUNTY	AGRIPOST, INC.	BEDMINSTER BIOCONVERSION	RESOURCE RECOVERY INC.	BERRIEN COUNTY RES. REC. AUTH.
OPERATOR	LAKE OF THE WOODS	SWIFT COUNTY	AGRIPOST, INC.	VITAL EARTH RESOURCES	RESOURCE RECOVERY INC.	BERRIEN COUNTY RES. REC. AUTH.
START DATE	1989	1990	1989	1972	N/A	1988
COMPOST FEEDSTOCK	MSW	MSW	MSW	MSW (10-1)	MSW	MSW
DESIGN CAPACITY (T/D)	5 - 10	25	350	25 MSW; 12 SLUDGE	80	7 COMPOSTING
TIPPING FEE ($/T)	SERVICE FEE (7-1)	68	26	(10-2)	15	N/A
CAPITAL COST ($)	411,000 (7-2)	1,615,900 (8-1)	30 MILLION	(10-3)	N/A	N/A
OPERATING COSTS ($/YEAR)	264,769	255,536	N/A	300,000	N/A	N/A
AMT. OF COMPOST PRODUCED (TPY)	NOT AVAILABLE	N/A	N/A	N/A	N/A	N/A
AMT. OF COMPOST MARKETED (TPY)	N/A	N/A	15,000 BY 12/90	N/A	N/A	N/A
PRICED REC. FOR COMPOST ($/CY)	NONE	NONE	NONE	12	NONE	NONE
COMPOST METHOD	WINDROW	WINDROW	WINDROW	DIGESTER/TURNING	WINDROW	WINDROWS
REJECT DISPOSAL COSTS ($/T)	NONE (CTY. LDFL.)	44	VARIES	N/A	USES OPER. LANDFILL	N/A
POPULATION SERVED	3,900 (8,000 MAX.)	12,000	250,000	DEMONSTRATION ONLY	N/A	N/A
WEIGH WASTE	NO	YES	YES	NO	N/A	N/A
SHRED WASTE	YES	YES	YES	NO	NO	YES
TURNING METHOD	FRONT END LOADER	FRONT END LOADER	WINDROW TURNING	FRONT END LOADER	CUSTOM (11-1)	N/A
HOUSEHOLD HAZ. WASTE DIVERSION	YES	NO	NO	NO	NO	N/A
SOURCE SEPARATED WASTE	YES	YES	NO	NA	NA	NA
MAJOR OPERATIONAL PROBLEMS	INEFFICIENT COMPOSTING	INEFFICIENT COMPOSTING	TERTIARY SHREDDER UNDERSIZED FOR PRIMARY/SECONDARY SHREDDERS ; ODORS	NONE REPORTED	MARKETS FOR COMPOST	N/A
REFERENCES	152,206,207,213, 314,741,733,738,737, 750	206,207,733,738,737, 750	154,206,207,213, 246,394,752,741, 737,750	52,128,154,207, 741,738,762,750	738,731,750	738,731,750

TABLE G-1. MSW COMPOSTING FACILITIES IN THE U.S. (Cont)

PARAMETER	TRS INDUSTRIES CO-COMPOSTING FACILITY FACILITY #13	RIEDEL OREGON COMPOST COMPANY FACILITY FACILITY #14	ADDINGTON ENVIRONMENTAL, INC. COMPOST FACILITY FACILITY #15	PENA-AYALA COMPANY COMPOSTING FACILITY FACILITY #16
LOCATION	DES MOINES, IA	PORTLAND, OR	ASHLAND, KY	EDINBURG, TX
OWNER	TRS INDUSTRIES	RIEDEL (14-1)	ADDINGTON ENVIRON. INC.	PENA-AYALA COMPANY
OPERATOR	TRS INDUSTRIES	REIDEL ENVIRON. TECHNOLOGIES	ADDINGTON ENVIRON. INC.	PENA-AYALA COMPANY
START DATE	MARCH 1991	APRIL 1991	JAN. 1991 (15-1)	FEBRUARY 1991
COMPOST FEEDSTOCK	MSW+SEWAGE SLUDGE	MSW	MSW, SLUDGE, MANURE	MSW
DESIGN CAPACITY (T/D)	200 MSW (13-1)	600	100 - 150	70 - 80
TIPPING FEE ($/T)	21.63 (MSW+SLUDGE)	68	N/A	N/A
CAPITAL COST ($)	4.2 MILLION	30 MILLION	N/A	N/A
OPERATING COSTS ($/YEAR)	N/A	5 MILLION	N/A	N/A
AMT. OF COMPOST PRODUCED (TPY)	N/A	175 TPD	N/A	N/A
AMT. OF COMPOST MARKETED (TPY)	NOT AVAILABLE	N/A	N/A	N/A
PRICED REC. FOR COMPOST ($/CY)	NONE	N/A	N/A	N/A
COMPOST METHOD	WINDROWS	AERATED STATIC PILE	WINDROW	WINDROW
REJECT DISPOSAL COSTS ($/T)	N/A	N/A	N/A	N/A
POPULATION SERVED	N/A	N/A	N/A	N/A
WEIGH WASTE	N/A	YES	N/A	N/A
SHRED WASTE	YES	NO	YES	YES
TURNING METHOD	WINDROW TURNING	NONE	N/A	N/A
HOUSEHOLD HAZ. WASTE DIVERSION	N/A	N/A	N/A	N/A
SOURCE SEPARATED WASTE	NA	NO	NA	NA
MAJOR OPERATIONAL PROBLEMS	N/A	N/A	LANDFILL USED FOR REJECTS, CLOSED BY STATE	N/A
REFERENCES	154,213,207, 738,731,750	207,246,750	731,738,750	154,207,750

TABLE G-1. MSW COMPOSTING FACILITIES IN THE U.S. (Cont)

KEY TO FOOTNOTES:

(1-1) 1000 TPD MSW RECEIVED, MAJORITY DIVERTED TO COMBUSTION FACILITY.

(1-2) CAPITAL COST IS $71,545,000 ($27,598,000 FOR SOLID WASTE PROCESSING COMPONENT, AND $43,927,000 FOR COMPOSTING COMPONENT ONLY).

(1-3) OPERATING COSTS FOR 1989: $30,212,408 ($8,322,526 FOR COMPOST COMPONENT ONLY).

(2-1) CAPACITY: ALSO 21,000 GALLONS OF 2-3% SOLIDS SLUDGE EVERY TWO WEEKS.

(2-2) OPERATING COSTS: INCLUDE $70,000 FOR SALARIES. O&M IS $13/T; $35/T, INCLUDING DEBT SERVICE.

(2-3) PROBLEMS: CRACK DEVELOPED IN THE AGED CEMENT-KILN USED AS THE DIGESTER VESSEL.

(3-1) OWNER: RECOMP, INC. WITH OTHERS AS ST. CLOUD TRANSFER AND RECYCLING, INC.

(3-2) FEEDSTOCK: SLUDGE DISCONTINUED IN LATE 1989.

(3-3) CAPACITY: 100 TPD TO COMPOST PROCESSING, WHICH IS LOCATED AT A TRANSFER STATION WHERE 300 TPD OF WASTE IS TRANSFERRED TO RDF FACILITY.

(3-4) CAPITAL COST: $1.5 MILLION IN MODIFICATIONS IS PLANNED.

(3-5) MARKETS: FARM FIELDS, HIGHWAY LANDSCAPING, LANDFILL COVER, COMMERCIAL LANDSCAPING, MINED LAND RECLAMATION.

(3-6) PRICE OF COMPOST: $4/CY FOR LANDSCAPE GRADE; $8/CY FOR HORTICULTURAL GRADE.

(4-1) TIPPING FEE IS $70/T IF MSW IS NOT SEPARATED; $30/T IF SEPARATED INTO THREE COMPONENTS OF RECYCLABLES, COMPOSTABLES AND LANDFILL RESIDUE.

(6-1) CAPITAL COST FUNDING CONSISTS OF A STATE GRANT/LOAN OF $782,000 FOR THE RDF FACILITY.

(7-1) TIPPING FEE IS ACTUALLY A SERVICE FEE OF $2.12/HOUSEHOLD/MONTH.

(7-2) CAPITAL COST IS $411,000 AS 1/92 -- $230,453 FOR BUILDING AND BALANCE OF EQUIPMENT. A GRANT/LOAN OF $399,550 HAS BEEN PROVIDED BY THE STATE.

(8-1) CAPITAL COST IS FUNDED WITH A GRANT FROM THE STATE OF MINNESOTA FOR $711,000.

(10-1) COMPOST FEEDSTOCK CONSISTS OF MSW AND SEWAGE SLUDGE FOR DEMONSTRATIONS; AND AGRICULTURAL WASTE, BREWERY SLUDGE AND SAWDUST FOR SOIL PRODUCTION BUSINESS.

(10-2) FACILITY OPERATED WITH MSW AND SLUDGE AS DEMONSTRATION.

(10-3) CAPITAL COSTS: INITIAL INVESTMENT OF $250,000 IN 1971 WITH ADDITIONAL INFUSION OF $500,000 SINCE 1982.

(11-1) TURNING METHOD IS A CUSTOM BUILT MIXER/FLUFFER WHICH IS DESIGNED TO BREAK BAGS AND MIX WASTE.

(13-1) CAPACITY IS 200 TPW MSW AND 30,000 WET TONS PER YEAR OF SLUDGE.

(14-1) OWNERSHIP IS WITH RIEDEL WITH TURNKEY TO PORTLAND METROPOLITAN DISTRICT.

(15-1) ALTHOUGH STARTED UP IN JANUARY 1991, THE FACILITY WAS TEMPORARILY CLOSED IN THE SPRING OF 1991.

G.2.2.1 Delaware Reclamation Project, Wilmington, Delaware

Designed as a full-scale research and demonstration facility, the Delaware Reclamation Project (DRP) is by far the most highly mechanized MSW processing facility now operating in North America. It processes 1,000 TPD of MSW, and 350 TPD of sewage sludge from the municipal wastewater treatment plant. Products generated by the DRP are refuse-derived fuel (RDF), 103,000 TPY; ferrous metals, 18,000 TPY; glass, 1,800 TPY; nonferrous metals, 1,300 TPY; and compost, 37,000 TPY. About 8,660 TPY of residue remains.

G.2.2.1.1 Process Description. Figure G-1 depicts the overall process. After weighing at the scale house, MSW is dumped on the floor inside the tipping and storage building; the storage capacity is 1,800 tons. Front-end loaders push the refuse onto metal pan conveyors which carry it to one of two primary hammermill shredders, each with a capacity of 70 tons per hour. The shredders reduce the feed material's particle size to 4 to 12 inches.

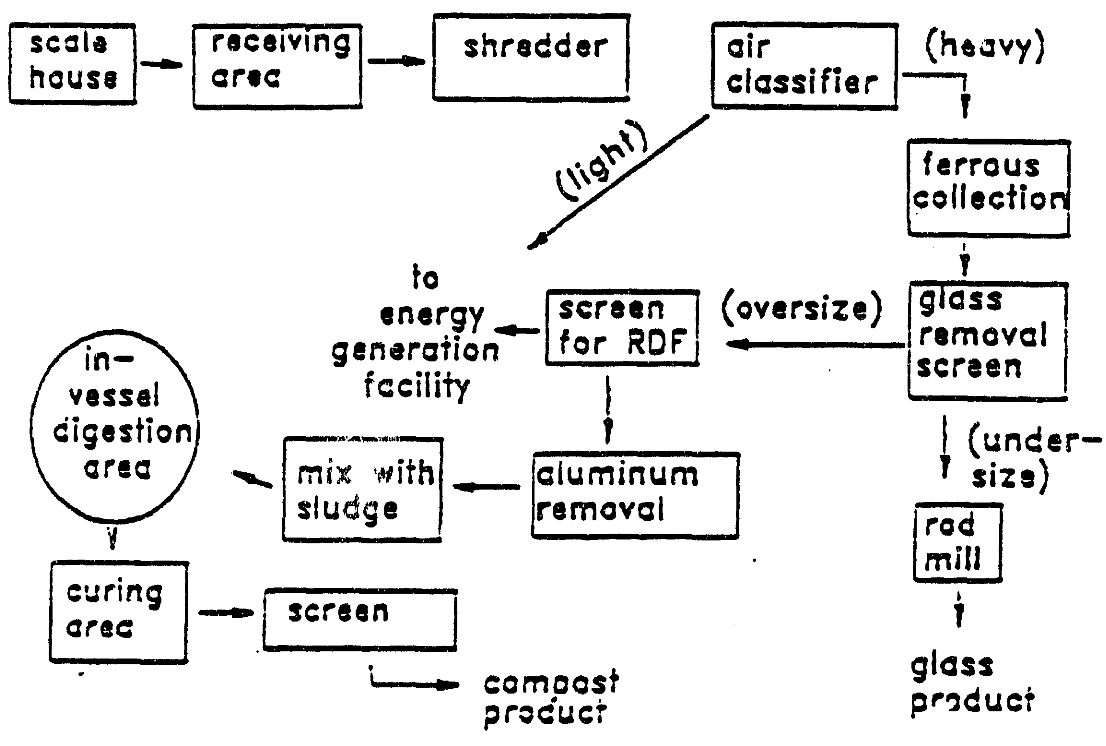

Figure G-1. Delaware Reclamation Project - MSW Composting Process (741)

Shredded MSW moves on enclosed conveyors to the Dry Process Building where two rotary drum air classifiers separate the MSW into a light and a heavy fraction. The light fraction is the major component of the RDF product. The heavy fraction is conveyed to the ferrous separation system where it passes under a magnet which removes the majority of the ferrous metals. A secondary drum magnet then removes the light ferrous fraction.

The remaining heavy fraction is conveyed to the Wet Process Building where a 9-foot diameter trommel with 2-inch screen holes separates out small particles of glass, ceramics, stones, metal and organic materials. These materials are then screened to a minus 3/4 inch size. The trommel oversize particles are discharged into a second 11-foot diameter trommel with 5-inch screen holes to separate material consisting mostly of textiles and plastic for RDF. The undersize material is conveyed to the Humus Process Building.

The minus 3/4-inch material from the primary trommel proceeds to an organic removal jig, where a jigging motion in a water bath allows fibrous organics to rise to the water surface and float to a screen where the water is squeezed out; the organic material is conveyed to the composting plant. The washed heavier fraction flows over a weir at the end of the jig and through a rod mill where it is crushed and screened through a 20-mesh vibrating screen. The undersize material goes to two banks of flotation cells where the addition of an amine acetate solution renders glass particles hydrophobic so that air bubbles can float them to the surface where the glass is skimmed off by rotating paddles. The glass particles are then dewatered, dried, and magnetically cleaned to prepare them for market.

The non-glass particles settled out in the flotation cells are pumped to a clarifier to treat water for reuse in the jigging, grinding, and screening operations. The settled material in the clarifier is dewatered by a rotary vacuum drum filter, and landfilled.

The air classifier heavy fraction, after removal of ferrous metals and glass in the processes just discussed, is conveyed to an aluminum separator which uses eddy currents to move aluminum onto a belt conveyor leading into a roll-off container.

Digested sewage sludge at 20 percent solids is dumped from trucks into one of three live bottom receiving hoppers. The sludge is mixed with the organic product from the jig in a cage mill (solid waste/sludge at a ratio of 4:1) and conveyed to one of four circular, dome covered digesters.

Each digester has a rotating bridge which consists of a feed mechanism for the incoming MSW/sludge mixture and augers to mix and move the material. Air is forced through the digester to maintain aerobic composting conditions. The material retention time in the digesters is 5 to 7 days.

The partially composted material is then discharged by conveyor and loaded into trucks for disposal in the adjacent landfill or cured and screened to minus 1/4 inch to be marketed as "Fairgrow"; a compost product used for horticultural and landscaping applications. Although 37,000 tons of compost are produced per year, only 500 tons were marketed in 1990 with the remainder sent to landfill.

Table G-2 summarizes the heavy metal content of the Fairgrow product, along with that of compost from four other facilities, and the mean sludge metal content from the U.S. EPA National Sewage Sludge Survey (752).

G.2.2.1.2 Discussion. One major challenge for the composting facility has been control of odors, particularly from the digesters. A variety of process management alternatives have been tried over the years to control odors from the digester, such as varying air flow rates and pH. For the last two years, odors have been treated rather effectively by spraying a proprietary material, Deamine, into the exhaust air from the plant. In addition, odor masking agents are used on the tipping floor and at other locations throughout the plant.

Difficulties have also occurred in marketing of the Fairgrow compost product due to a lack of state regulations for compost material, as well as elevated levels of PCB and heavy metals, particularly nickel and lead (750).

TABLE G-2. HEAVY METALS IN MSW COMPOST FROM SELECTED OPERATING FACILITIES

(752)

METAL	AGRISOIL (a) MEAN (mg/kg)	FAIRGROW (b) MEAN (mg/kg)	FILLMORE (c) MEAN (mg/kg)	ST. CLOUD (d) MEAN (mg/kg)	SUMTER (e) MEAN (mg/kg)	SLUDGE (f) MEAN (mg/kg)
Cd	4.1	3.4	2.9	2.2	5.0	6.9
Cr	20.5	223	12.8	33.5	-	119
Cu	246	285	101.5	180	250	741
Hg	2.4	4.0	1.2	1.8	-	5.2
Ni	34	77	15.1	28	27	43
Pb	124	496	82.4	185	290	134
Zn	607	1008	329	390	580	1202

METAL	AGRISOIL (a) RANGE (mg/kg)	FAIRGROW (b) RANGE (mg/kg)	FILLMORE (c) RANGE (mg/kg)	ST. CLOUD (d) RANGE (mg/kg)	SUMTER (e) RANGE (mg/kg)
Cd	ND - 8.3	2.3 - 7.0	1.4 - 4.4	1.3 - 3.0	3.1 - 8.2
Cr	2.1 - 43.4	159 - 828	9.3 - 16.2	23 - 44	- - -
Cu	5.1 - 1053	190 - 972	101 - 102	110 - 250	240 - 260
Hg	1.5 - 3.2	0.6 - 5.9	0.1 - 1.4	0.7 - [illegible].2	- - -
Ni	3.2 - 99	139 - 709	12.4 - 17.8	20 - 36	14 - 49
Pb	<.6 - 287	348 - 1250	- - -	140 - 230	280 - 300
Zn	4.1 - 4886	596 - 1370	328 - 330	310 - 470	560 - 600

FOOTNOTES:

(a) Agrisoil: Dade County, FL. Agripost, Inc. MSW compost, 2/13/90: 22 sample test, mean value and range indicated. (Source: ICF Laboratories, Fairfax, VA)

(b) Fairgrow: Wilmington, DE. MSW compost and sludge, 1989: 12 sample test, mean and range for a 12 month period. (Source: Delaware Solid Waste Authority, Wilmington, DE)

(c) Fillmore County, MN. MSW compost, 9/20/89 and 3/30/90: One sample test each. (Source: Minnesota Valley Testing Laboratories, Inc., New Ulm, MN)

(d) St. Cloud, MN. MSW compost, 11/17/89 and 5/15/90: One sample test each. (Source: Serco Laboratories, St. Paul, MN)

(e) Sumter county, FL. MSW compost, 4/9/90: One month sample. Values obtained from average of three sub-sample analyses. (Source: Envirolab, Inc.)

(f) Mean sludge metal contents from a national sewage sludge survey.

NOTE: Metal concentrations expressed as mg/kg, dry weight.

G.2.2.2 Portage, Wisconsin Co-Composting Facility

G.2.2.2.1 Process Description. Figure G-2 is a diagram of the co-composting process at the Portage facility. After being weighed at the scale house, MSW is dumped onto the tipping floor which is designed to hold 150 tons of waste inside the facility building. Large non-compostable items are removed by hand and front-end loader. The loader then moves the unsorted and unshredded waste into a loading compartment from which a hydraulic ram pushes the material into the rotating digester. At the same time, a pump injects sludge at 2 to 3 percent solids content from an underground storage tank into the drum at a predetermined proportion to the amount of MSW (about 35 gallons per ton MSW). The digester is a 160 foot long, 11 foot in diameter salvaged cement kiln, inclined at a slope of 3 degrees from the feed end to the discharge end. The digester is powered by a 70 horsepower electric motor which rotates the drum from 30 to 60 revolutions per hour. Retention time is approximately 2 weeks.

Metal rods attached to the sides of the inside of the digester assist in breaking open trash bags and reducing the particle size of the waste. The tumbling of the waste against itself, and the generation of acidic liquids further serve to reduce the particle size (750).

Oxygen is provided for the composting process by drawing air in from the discharge end of the digester with a fan at the feed end, which then exhausts moisture and gases to the atmosphere. Composting temperatures of 60 to 65 degrees C are maintained to provide pathogen reduction. Temperature monitoring ports are provided in the wall of the digester.

A two-stage scalloping screen is attached to the discharge end of the digester. Oversize material from both screen stages is landfilled. The screen undersize material (minus 3/4 inch) is conveyed outside and deposited in a pile. It is then taken to a one-acre curing pad where the piles are turned about once each month. Leachate from the curing pad drains to a 250,000 gallon clay-lined lagoon which is pumped out as needed and taken to the municipal wastewater treatment plant for disposal. A small hammermill is used occasionally to further process the compost for use in test projects.

G.2.2.2.2 Discussion. Due to a lack of MSW compost product regulations in Wisconsin, use of the compost has been restricted to landfill cover and research projects. A major state-funded project, started in 1990, uses the compost on a variety of crops and soil types to provide information for development of Wisconsin compost regulations (750). The City is evaluating methods to remove glass and other inert materials from the compost. In the spring of 1991, it was reported that the digester developed a crack which resulted in a temporary facility shutdown (750).

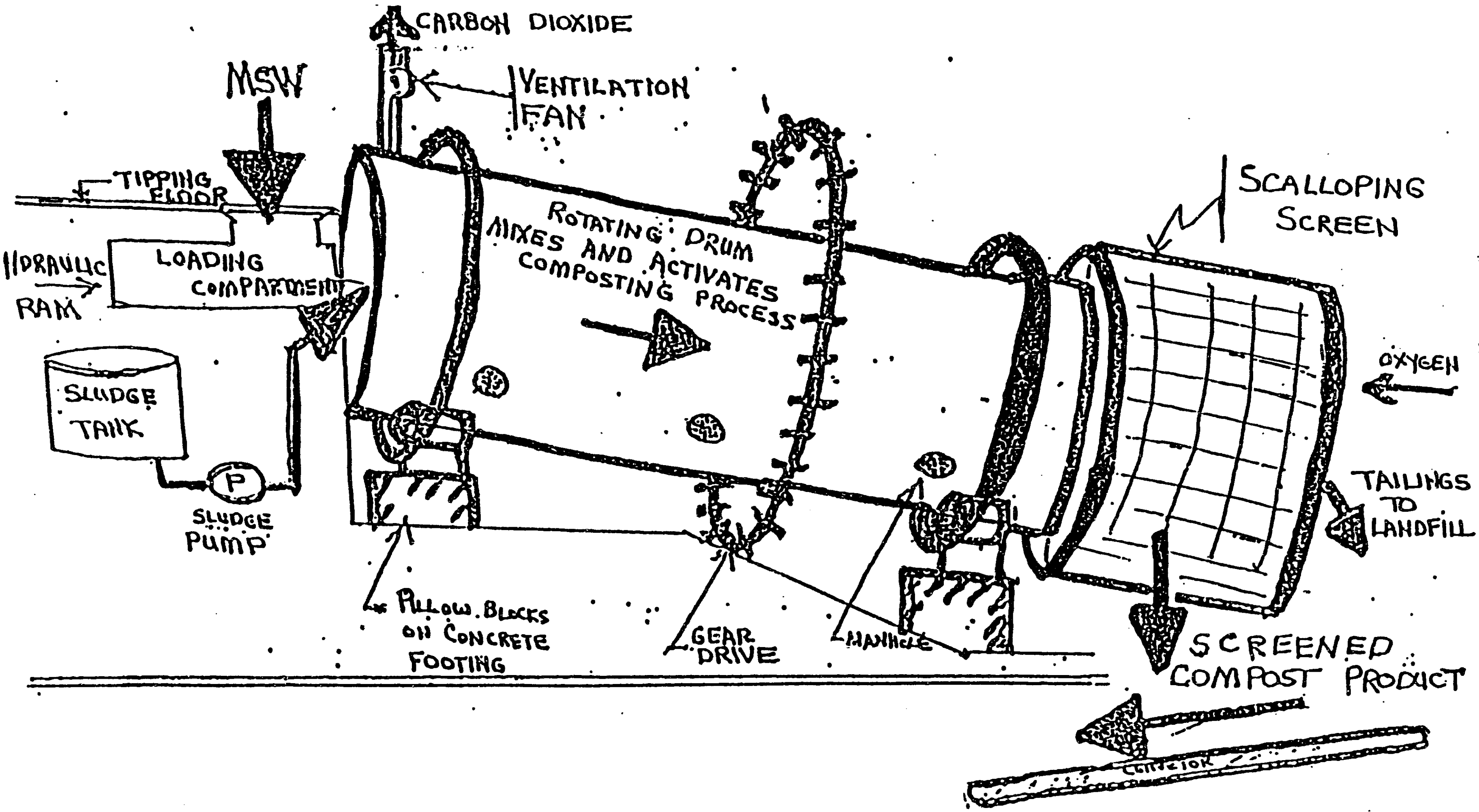

Figure G-2. Portage, Wisconsin Co-composting Facility Process (762)

G.2.2.3 Recomp, Inc. Composting Facility, St. Cloud, Minnesota

G.2.2.3.1 Process Description. Figure G-3 diagrams the Recomp process. After weighing, MSW is dumped onto the tipping floor where it is inspected for oversize, non-compostable items which are pulled aside and pushed by front-end loader into a transfer trailer. A front-end loader then lifts the waste onto a conveyor which feeds into a bag opener and then to a trommel with 7-inch openings. Oversize material from the trommel is taken to an RDF facility. Undersize material is conveyed under a magnet to remove ferrous metals, and then to the digesters. A hydraulic ram pushes the waste into one of two rotating drum digesters, each with a capacity of 50 TPD. The moisture content of the feed material is adjusted with water pumped into the digester from an outside storage tank.

The digesters are inclined towards the discharge end, and are 120 feet long and 12 feet in diameter. The first digester was constructed as an Eweson digester, and has three compartments separated by two transfer doors, with waste spending one day in each chamber before being discharged. It rotates at about 25 revolutions per hour, aerating the waste and reducing its particle size. The three chambers are designed to isolate the higher temperature thermophylic composting stage in the middle chamber from the start-up and cool-down stages in the first and third chambers, respectively (762). A fan draws air from the discharge end of the digester up through the second and first chambers where it is discharged to the atmosphere. On a daily basis, the discharge gate is opened in the third chamber and partially composted waste is emptied onto a conveyor belt and transferred outside to an enclosed trommel with a 1-1/2 inch screen. The door between the second and third chambers is then opened and waste is transferred into the third chamber. The process is repeated from the first to second chamber, leaving from 10 to 20 percent material in the first chamber to inoculate the next batch of feed material. The second digester was installed in late 1989 and is reportedly different from the first digester in that it has two chambers instead of three (750).

Pathogen destruction temperatures of 42 to 55 degrees C are achieved for a portion of the time waste is in the digesters. Material which is to be further processed is then composted in windrows on a pad next to the building. The windrows are turned with a front-end loader based on temperature readings.

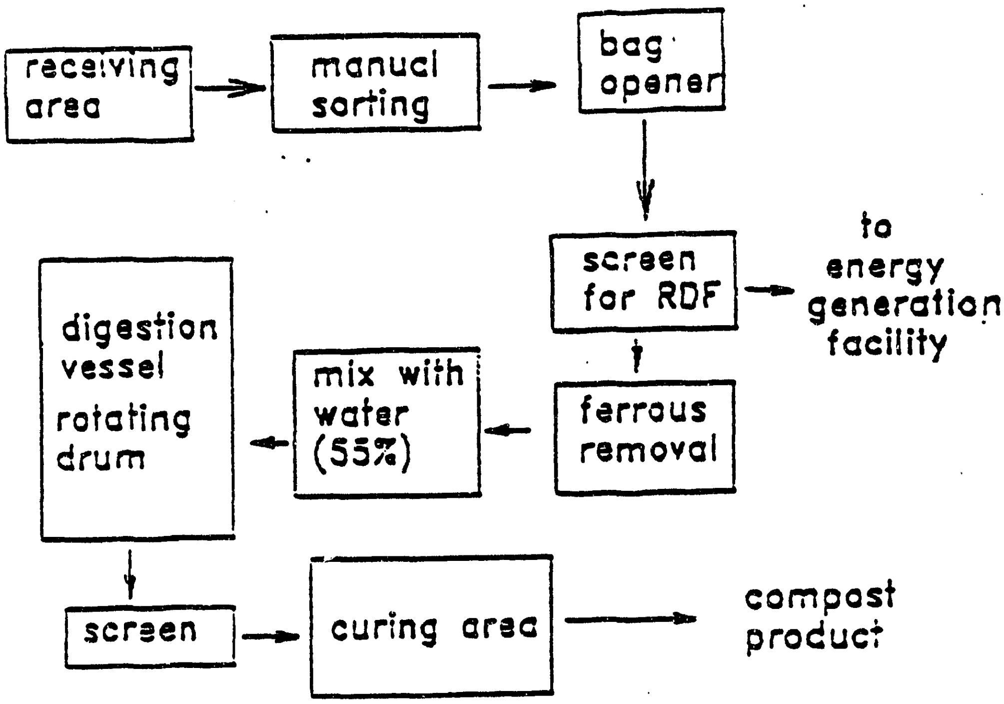

Figure G-3. Recomp, Inc. MSW Composting Facility, St. Cloud, MN, Process (741)

Curing times vary depending on intended markets, with 40 days for a landscape grade product and 100 to 120 days for horticultural grade. The final product is then screened before being distributed. Applications include farm field use, highway landscaping, landfill cover, commercial landscaping and mined land reclamation.

Tables G-2 and G-3 present the results of nutrient and pollutant tests of Recomp's St. Cloud compost, showing that it meets the Minnesota heavy metal standards for a Class I material.

TABLE G-3. CHARACTERISTICS OF FINISHED COMPOST PRODUCT[a] RECOMP, INC. ST. CLOUD, MN FACILITY AND REGULATORY LIMITS (741)

	Number of Samples	Mean	Standard Deviation	Class I Regulatory Limits[b]
		(%)by weight	(%) by weight	(%) by weight
Total solids	26	63.66	9.38	–
Volatile solids	20	44.82	10.01	–
Kjeldahl nitrogen	22	1.14	0.28	–
Ammonia	20	0.16	0.06	–
Nitrates	15	<0.41	0.78	–
Nitrites	7	0.36	0.82	–
Total phosphorous	14	1.5	1.99	–
Potassium	15	0.49	0.04	–
Calcium	2	9.84	4.47	–
Iron	2	0.65	0.13	–
Magnesium	1	0.23	–	–
Manganese	1	0.02	–	–
Sodium	1	0.49	–	–
Aluminum	1	1.08	–	–
		(mg/Kg)	(mg/Kg)	(mg/Kg)
Boron	3	10.67	5.58	–
Cadmium	21	2.2	0.76	10
Chromium	3	30.4	9.24	1000
Copper	20	122	82.25	500
Lead	24	186	33.62	500
Mercury	19	0.88	0.21	5
Molybdenum	1	< 10.0	–	–
Nickel	24	23.2	7.7	100
Selenium	1	<0.12	–	–
Zinc	20	364	65.0	1000
PCB	5	< 1.0	0.0	10
pH	21	8.3	0.33	–
Fecal Coliform	1	85	–	–

[a]Serco Laboratories, 1989, 1990
[b]Minnesota Pollution Control Agency, 1989

G.2.2.3.2 Discussion. Like many MSW composting facilities, operations at the St. Cloud plant have changed over time. The first digester was installed prior to Recomp's purchase of the facility in 1988. The facility was originally a transfer station, with the composting portion subsequently added. Consequently, space within the process building and on the general site is very limited, a fact that has contributed to operational problems.

The compost curing pad is too small for the quantity of material discharged by both digesters. The resulting excessively large windrows cannot be adequately aerated. Anaerobic conditions result within the pile causing unpleasant odors. Another cause of odor is the poorly designed drainage system for the curing pad. Water ponds under the pile, turns septic, and odors are released. An enclosed curing system is planned and until then, the facility is limited in the amount of material that can be windrow composted on site. Plans also include the installation of a negative pressure ventilation system throughout the plant, with exhaust air to be treated prior to discharge.

G.2.2.4 Fillmore County Composting Facility, Preston, Minnesota

Fillmore County utilizes a "three stream" waste collection system to minimize the amount of sorting at the composting facility. Recyclable items, compostable items, and landfill rejects are kept separate at the source of waste generation. A financial incentive to source separate is provided with a $70 per ton tip fee for unsorted material compared to a $30 per ton tip fee for sorted material.

G.2.2.4.1 Process Description. After weighing, waste is dumped onto a tipping floor and loaded by front-end loaders onto conveyors where bags of waste intended for composting are opened by hand, and manually sorted to remove any recyclable items. The source-separated recyclables are also sorted by hand, and then glass is crushed according to color, textiles are baled, newspapers are shredded and baled, and metals and plastics are baled. Six employees are used for the hand-sorting operations.

After manual sorting, the conveyed material passes under two magnets to remove ferrous metals and then into a low rpm shear shredder to reduce particle size to 4 inches. The moisture level of the waste is adjusted to about 55 percent in a silage mixer. The material is then taken by front-end loader to the outdoor composting area and piled in windrows. The windrows are turned by the front-end loader weekly or as needed depending on weather conditions, for a total composting period of from 10 to 14 weeks. The temperature of the windrows is not always monitored but testing has shown a nominal pile temperature of 71 degree C within 48 hours. When composting is judged to be complete, the compost is trommelled with a 1/2-inch screen. The oversize material is taken to landfill, and the compost is piled on-site for use by the public at no charge. Other markets include landfill cover, farms, and nurseries.

Tables G-2 and G-4 present the results of nutrient and pollutant tests of the Fillmore County compost, showing that it meets the Minnesota heavy metal standards for a Class I material.

G.2.2.4.2 Discussion. The major operational challenge for the Fillmore County composting facility has been moisture management. The facility was constructed to have the windrow composting take place within the building. However, due to inadequate space and poor ventilation for moisture removal, the composting operation was moved outside. Without adequate ventilation, the compost became too wet to screen and ice built up inside the building. Moisture continued to be a problem even with the pile outside due to seasonal precipitation; in 1990, very little compost was dry enough for final screening. Fillmore County is seeking state grant assistance in 1991 to construct a covered compost area on a concrete pad, and to purchase a windrow turning machine.

G.2.2.5 Sumter County Composting Facility, Sumterville, Florida

G.2.2.5.1 Process Description. After waste is weighed at the scale house, it is dumped on the tipping floor (3 to 4 days of waste storage capacity) and then loaded onto conveyors which carry it to a single-[illegible] flail mill that opens bags, liberating the contents. The material spills onto a conveyor, passes under a nagnet for ferrous metals removal, and proceeds to the hand picking area where plastic, aluminum, and cardboard are removed. The waste passes through a metal detector to alert workers of objects that could damage the secondary shredder, a double-rotor flail mill which reduces the particle size to 2-3 inches. Water is then added to the shredder discharge material to achieve a 50 to 60 percent moisture content.

A proprietary inoculum, described as a "biodynamic" enzyme/bacteria compound is added to the compost feedstock and outdoor windrows are constructed on a 1.5-acre curing pad (154). Due to insufficient space on the pad, shredded waste is being temporarily buried under a thin layer of soil in the landfill, presumably to be excavated and composted later when a 5-acre curing pad is constructed. A windrow turning machine is used durnig the 6-8 week composting period, with temperatures reaching 71 degree C.

TABLE G-4. SELECTED CHARACTERISTICS OF THE FILLMORE COUNTY, MN FINISHED COMPOST[a] COMPARED TO CLASS I REGULATIONS (741)

	Concentration[a] (n=1)	Mean[b] (n=15)	Maximum Levels Allowed
	(%)	(%)	(%)
Nitrogen	1.0	0.92[c]	–
Carbon	–	30.77[c]	–
Kjeldahl-Nitrogen	0.42	–	–
Ammonia-Nitrogen	0.001	–	–
Nitrate-Nitrogen	0.0004	–	–
P_2O_5	0.5	–	–
Potassium	–	0.35	–
K_2O	0.5	–	–
Total Solid	66.50	–	–
Total Volatile Solids	16.25	–	–
	(mg/Kg)	(mg/Kg)	(mg/Kg)
Cadmium	1.41	2.35	10
Chromium	16.2	63.67	1000
Copper	102.3	121.93	500
Lead	82.4	197.13	500
Mercury	1.35	–	5
Nickel	17.8	34.27	100
Total Phosphorus	0.21	0.29	–
Zinc	328.5	487.14[d]	1000
PCB's	<0.5	–	1
C:N	13.0	35.7[c]	–
pH	5.8	–	–

[a]Minnesota Valley Testing Laboratories, Inc. 1989
[b]Environmental Consulting Technology, Inc., 1991
[c]n=13
[d]n=14

A 1/4-inch screen is used for final processing of the compost. Tables G-2 and G-5 provide information on the quality of the compost. After stockpiling compost for more than a year in anticipation of new state compost product regulations, Sumter County received state approval for unrestricted distribution for an 80 ton batch of compost in 1990. Markets for Sumter County's compost include landscape gardeners, sod farms, and nurseries. Other materials recovered at the facility include ferrous and non-ferrous metals, plastic, glass, cardboard, and newspaper.

TABLE G-5. SELECTED CHARACTERISTICS OF THE SUMTER COUNTY, FLORIDA FINISHED COMPOST[a] AND REGULATORY LIMITS (741)

	Mean (n=3)	Regulatory Limits[b]
	(%)	(%)
Moisture	42	-
Total nitrogen	0.64	-
TKN	0.62	-
Nitrate-Nitrite	<0.02	-
Total phosphorous	0.11	-
Potassium	0.15	-
	(mg/Kg)	(mg/Kg)
Cadmium	5	15
Copper	250	450
Lead	290	500
Nickel	27	50
Zinc	580	900
pH	7.6	
Fecal Coliform(MPN/g)	<84	100

[a]Envirolab, 1991
[b]Florida Department of Environmental Control, 1989

G.2.2.5.2 Discussion. Sumter County has not implemented source separation recycling and relies on hand sorting at the facility to recover recyclable materials. Problems at the facility are related to a small (1.5 acre) composting pad which can not adequately contain the full discharge from the plant. Since the pad had been constructed over covered landfill, it had settled unevenly causing problems with turning the piles and drainage. A new 5-acre pad on an adjacent property is planned for construction in 1991. A larger windrow turning machine is also being considered to handle a larger amount of compost. Another anticipated improvement to the operation includes the installation of a leachate collection and treatment system for the existing and proposed curing pads. A larger capacity final compost screening plant is also anticipated, as are some modifications to the process line to recover a greater percentage of recyclables and to remove glass particles.

G.2.2.6 Pennington County Composting Facility, Thief River Falls, Minnesota

G.2.2.6.1 Process Description. Figure G-4 diagrams the process at the Pennington County composting facility. The technology utilized in the plant is the Lundell Recycling System. Waste is dumped onto the tipping floor, and then loaded onto conveyors for hand sorting of recyclable materials. The material is then carried past a magnet for ferrous metals removal and to a disk screen with 2-inch spacing. Oversize material from the screen goes through an air classifier to separate the light and heavy fractions. The light fraction is manually sorted before being fed to a high speed flail cylinder for size reduction to 2 inches. This shredded material then goes to two augers which produce densified RDF. In addition to RDF, the facility produces corrugated cardboard, aluminum, and plastics.

The undersize material from the disk screen and the heavy fraction from the air classifier go through a hammermill shredder to produce a 2-inch particle size. Water is added to adjust the compost feedstock moisture content to 50 to 60 percent.

The compost feedstock is conveyed to a roll-off container and deposited in windrows by a dump truck. Windrows are turned approximately twice each week with a windrow turning machine, and a spray truck adds moisture to the piles. Temperatures in the windrows reach 50 to 60 degrees C, with about 6 to 8 weeks required for the composting process.

Final processing is accomplished with a 3/4-inch screen. Compost quality data is not presented in the literature reviewed.

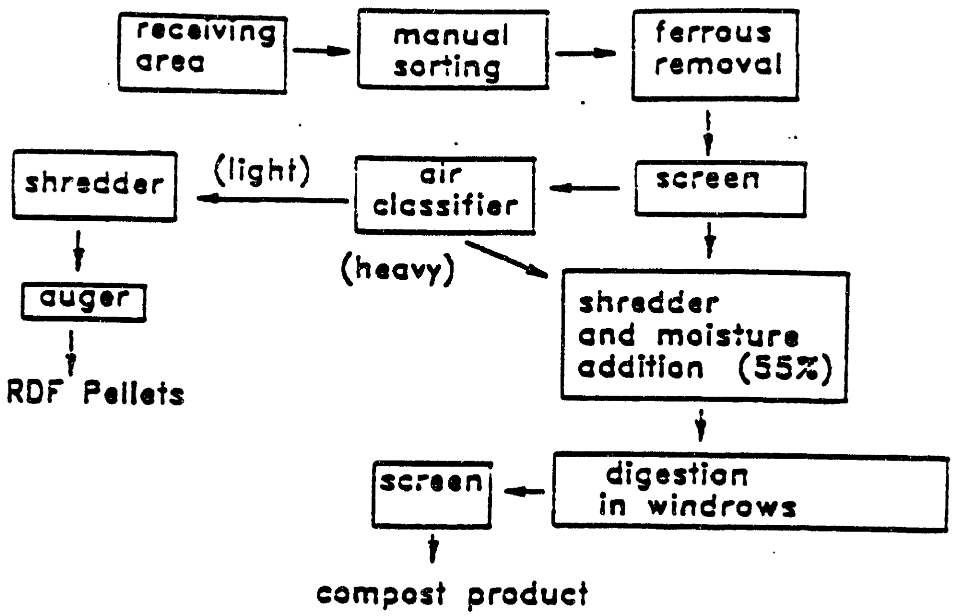

Figure G-4. MSW Composting Process, Pennington County, MN (471)

G.2.2.6.2 Discussion. The Pennington County facility has been operated primarily to produce RDF, although some composting has been conducted since 1986 (733, 724). Recent limited markets for RDF have resulted in greater attention to the composting component. Consultants had been hired to make recommendations for improving the compost operation. Improved screening equipment is being considered to enable the compost to meet state standards.

G.2.2.7 Lake of the Woods County Composting Facility, Graceton, Minnesota

Lake of the Woods utilizes a "three stream" source separation program where recyclables, compostables, and landfill material are kept separate (733, 724). The composting facility is located adjacent to the county landfill, and 12 miles away from the recycling facility in neighboring Baudette. No weighing of waste is conducted at the composting facility and homeowners or waste haulers deposit trash on the tipping floor adjacent to the processing area. This allows the unheated tipping area to be closed off from the processing and composting area during cold weather, conserving heat generated by the compost.

The county's mandatory separation program states that all compostable garbage must be free of all recyclables and landfill materials, and lists the following items as "compostable garbage": cardboard, newspaper, office paper, food scraps, food packaging, scrap paper, disposable diapers, magazines and books, paper bags, yard waste, cereal boxes, and fish waste. Even with mandatory separation, the county finds that about 10 percent of the "compostable only" waste stream contains recyclables.

G.2.2.7.1 Process Description. The waste is dumped into a hopper by a front-end loader and then conveyed through a wall into the processing area. It is inspected for recyclables and objects which may damage the downstream shredder. The waste then passes under a magnet and into a slow speed 50 hp shredder where it is reduced to a 2-inch particle size. The material is then conveyed to an agricultural type mixer where water can be metered in at a prescribed rate to achieve a moisture content of 55 to 60 percent. Waste is then conveyed through a wall to a pile in the 16,500-square foot composting room. The compost area is enclosed and has a ventilation fan in the middle of one of the exterior walls. After the windrows are constructed, the front-end loader turns the windrows about once per week.

The composting process takes about 6 to 8 weeks with temperatures reaching 60 to 71 degree C. A covered but open-sided curing area is attached to the composting area. A homemade trommel screen with 3/4-inch openings is used for final processing of the compost.

G.2.2.7.2 Discussion. The first year of operation at Lake of the Woods produced compost which the state recommended disposing of in the landfill because the material was not sufficiently degraded and stabilized. A state grant of $100,000 was awarded to the County to retain consultants to recommend improvements in operation of the plant, and to conduct research on worker health and safety at the facility.

Moisture management has been a challenge at Lake of the Woods, with very cold weather causing ice and fog build-up in the composting area, obscuring vision of equipment operators and making it extremely difficult to turn the piles. A better ventilation system is planned. It is also thought that insufficient moisture was being added to waste in the mixer in order to maintain adequate conditions for biological decomposition.

G.2.2.8 <u>Swift County Composting Facility, Benson, Minnesota</u>

Swift County is utilizing a "three stream" source separation program where residents are asked to keep recyclables separate from other materials, and separate other waste into two different colors of bags: black bags with "non-processible" wastes destined for the landfill, and white bags containing only compostable materials.

G.2.2.8.1 <u>Process Description</u>. After weighing at the scale at the entrance to the composting facility, the bagged waste is dumped onto an enclosed tipping floor. The bags are sorted by hand and those containing compostable materials are pushed with a skid loader onto a conveyor and into a rotating drum to break open the bags. An employee then uses a pitchfork to remove visible "non-processible" items for recycling or landfill. Waste is then shredded in a hammermill before passing by a magnet and into a trommel with a 1-inch screen. Oversize material from the trommel is conveyed to a pile in the adjoining composting room for landfill disposal. Undersize material is also conveyed to the composting room and built into windrows on top of aeration grates in the floor. Blowers are used to either positively or negatively aerate the windrows, and a front-end loader is used to turn the windrows once or twice per week. Moisture is added to the piles with a hose as needed. Leachate is collected in drains and applied to the windrows. The composting process takes approximately 6 months with temperatures ranging from 54 to 66 degrees C. After composting, the material is screened to a 1-inch particle size with the final product used for landfill cover. Table G-6 shows that the Swift County compost meets the state standards.

The Swift County facility also incorporates a materials reclamation facility for sorting and processing of source separated recyclables collected curbside. The various types of recyclables are dumped onto the tipping floor and loaded onto a conveyor where they are hand sorted by color of glass, type of plastic, etc. Glass is crushed, and cardboard and other materials are baled. Processed recyclables are stored in the facility until delivered to markets.

G.2.2.8.2 <u>Discussion</u>. The Swift County composting facility design was based on the assumption that source-separated compostable waste would be processed through the shredder and trommel and then into windrows for composting (733, 724). Therefore, no equipment other than a magnet and a trommel screen was installed to remove contaminants from the compost feed stream. Source separation was new to Swift County when the facility began operations in 1990, and inevitably some people failed to properly separate their materials. This created problems with the compost quality, since there was very little contaminant removal before or after shredding. The County expects this situation to improve as residents become more familiar with the program.

TABLE G-6. CHARACTERISTICS OF SWIFT COUNTY, MN FINISHED COMPOST[(a)] AND REGULATORY LIMITS (741)

		Regulatory Limits[c]
	(%) by weight[b]	(%) by weight
Carbon	53.43	–
Nitrogen	1.07	–
Phosphorous	0.22	–
Potassium	0.59	–
	–	
	(mg/Kg)	(mg/Kg)
Aluminum	10133	–
Boron	24	–
Cadmium	2	10
Calcium	15042	–
Chromium	21	1000
Cyanides	39	–
Iron	1631	–
Lead	98	500
Magnesium	2596	–
Manganese	515	–
Mercury	–	5
Nickel	8	100
Sodium	3789	–
Zinc	524	1000
C:N ratio	49.9	

[a]Class I compost is defined as compost without sewage sludge, (Minnesota Pollution Control Agency, 1989)
[b]n=1, Minnesota Extension Service, 1990
[c]Minnesota Pollution Control Agency, 1989

G.2.2.9 Agripost, Inc. Composting Facility, Dade County, Florida

G.2.2.9.1 Process Description. Figure G-5 depicts the existing Agripost composting facility process; proposed additional processing steps are also shown. The facility was closed in January 1991, and the proposed changes were never implemented. The tipping floor, five shredders, and compost area are enclosed within a 320,000-square foot building.

After trucks were weighed, waste was dumped on the tipping floor and pushed by loaders into two oscillating pits which spread out the waste and fed it onto two 50 TPH process lines. Oversized items and lead-acid batteries were removed by hand picking, and the material was conveyed to one of two primary hammermill shredders which shred particles to a size of 7 inches or less. A secondary shredder further reduced the particle size to 2 inches. The secondary shredder discharge was conveyed to hoppers for storage. The hoppers discharged into dump trucks which transported the material to the 6-acre composting area where it was formed into windrows. Shredded waste was reported to be treated with a proprietary liquid inoculant which reportedly stimulated the natural microbial decomposition process.

Front-end loaders built the shredded waste into windrows approximately 10 feet tall, 10 feet wide and 700 feet long. The material was turned every 2 to 4 days with windrow turning machines and composted for several weeks, with temperatures exceeding 60 degrees C in the piles.

After composting, the material went through a tertiary shredder and to a fine screening process using different size screens depending on intended markets for the compost. Oversize material from the screen was recycled back to the composting operation front end, or landfilled. The final product was cured for about one month for marketing in bulk sales or bagged as "Agrisoil." Table G-7 presents heavy metal concentrations of Agripost compost product compared to the State regulatory limits (741). According to the results, mean metal concentrations are below regulatory limits for a product with unrestricted use, but copper, nickel, and zinc were detected in some samples at concentrations that exceed the limits for a Code 1 product.

Uses for the Agripost product included landscaping, horticulture, agriculture and highway soil amendment.

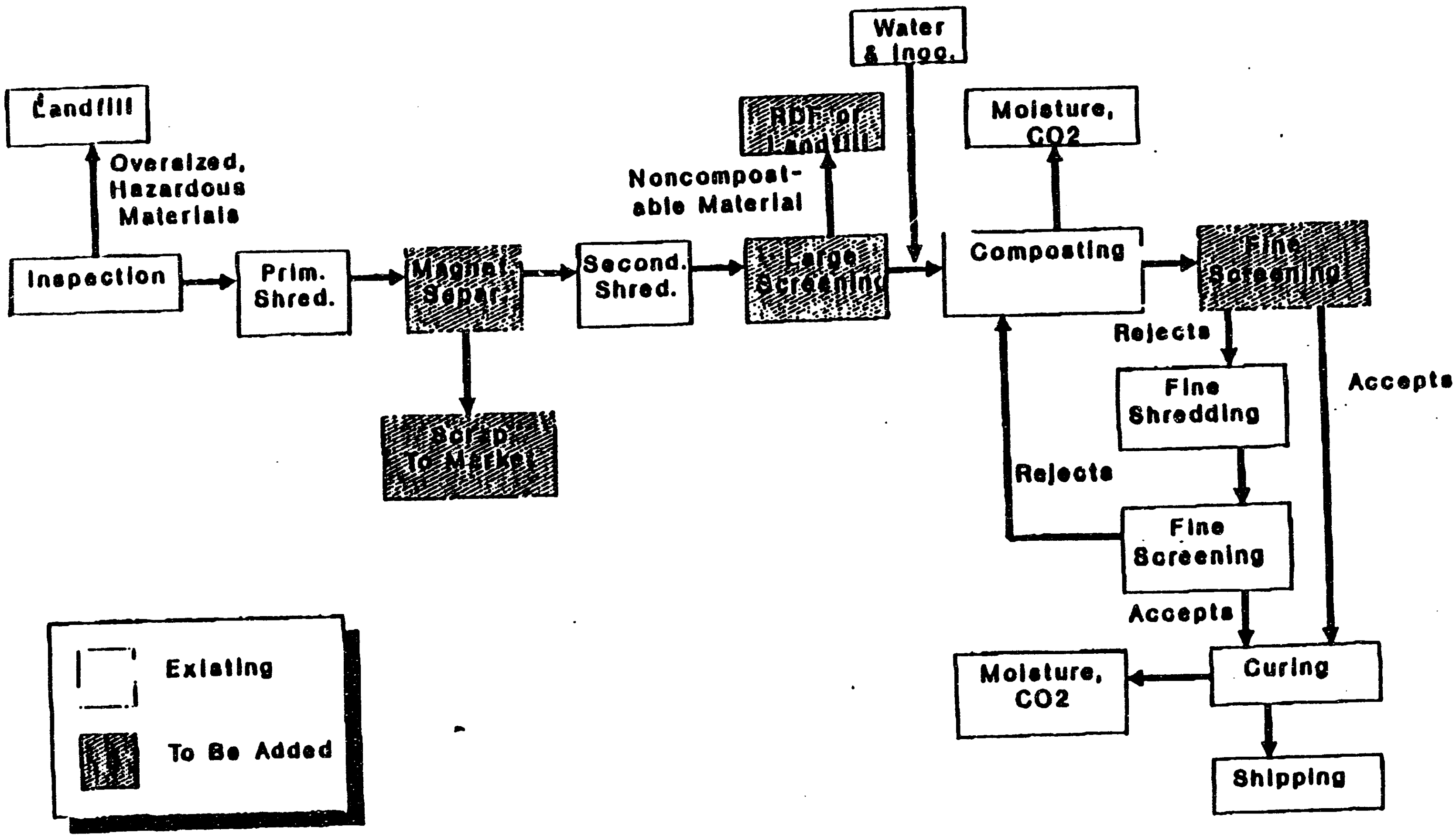

Figure G-5. Dade County, FL Composting Facility Process (741)

TABLE G-7. METALS CONCENTRATION OF AGRIPOST'S FINISHED COMPOST[(a)] AND FLORIDA REGULATORY LIMITS (741)

Metal	Mean (N= 22)	Standard Deviation	Regulatory limits (Code 1)[b]
	(mg/Kg)	(mg/Kg)	(mg/Kg)
Arsenic	3.7	2.6	–
Cadmium	4.1	1.8	15
Chromium	20.5	11.6	–
Copper	246	253	450
Lead	124	73	500
Mercury	2.4	0.4	
Nickel	42	26	50
Zinc	883	977	900

[a]Agripost, Inc. 1990
[b]Code 1 means unrestricted use of product is allowed

G.2.2.9.2 Discussion. A series of problems contributed to the closure of the Agripost facility in January, 1991, just over a year after starting operation. The facility was designed for 800 TPD but less than half that tonnage was typically processed due to an undersized tertiary shredder and screening operation. A related problem was that the site had only 2 acres of approved curing pad. Compost was being stored beyond the permitted boundaries of the facility, an action which was determined by the County to be in violation of the facility's zoning permit. That violation, combined with odor complaints from abutting residents and an elementary school, led to the zoning permit being revoked by the County.

Many questions were raised within the industry regarding the feasibility of Agripost's main marketing claim that they had less than 5 percent landfill reject with their three-stage shredding system. In November 1990, Agripost announced that they were going to modify their system to include removal of more inorganic material (as shown in Figure G-5). Further, Agripost requested an increase in the tipping fee charged to the County in order to finance modifications and studies ordered by the Metro-Dade Florida Department of Environmental Resources Management. Undertaken in November 1990, this series of improvements and studies included the installation of an odor control system, performance testing at full capacity, a report on types and quantities of air emissions, and a risk analysis of those emissions. Agripost failed to find financing to make the required improvements and closed the Dade County plant (394, 213).

G.2.2.10 Bedminster Bioconversion Corporation, Co-composting Facility, Big Sandy, Texas

G.2.2.10.1 Process Description. The Big Sandy co-composting facility process is depicted in Figure G-6. The facility was constructed in 1972 by Ambassador College to convert the college's solid waste into compost for use in reclaiming former cotton fields for construction of the college campus (750). The facility uses the Eweson digester, a 120 foot long and 11 foot diameter rotating drum with three chambers.

Incoming MSW is deposited on an outdoor concrete tipping pad. Oversize items are removed, and the waste is pushed into a hopper by a front-end loader. A hydraulic ram pushes waste into the digester, and a [illegible] controlled pump injects liquid sewage sludge from an adjacent storage tank into the vessel to achieve a carbon to nitrogen ratio (C:N) of 35:1 and a 50 percent moisture content. A centrifugal blower supplies air at 300 scfm to the digester in a direction opposite to that of the waste flow through the digester. The digester turns at 20 to 60 revolutions per hour.

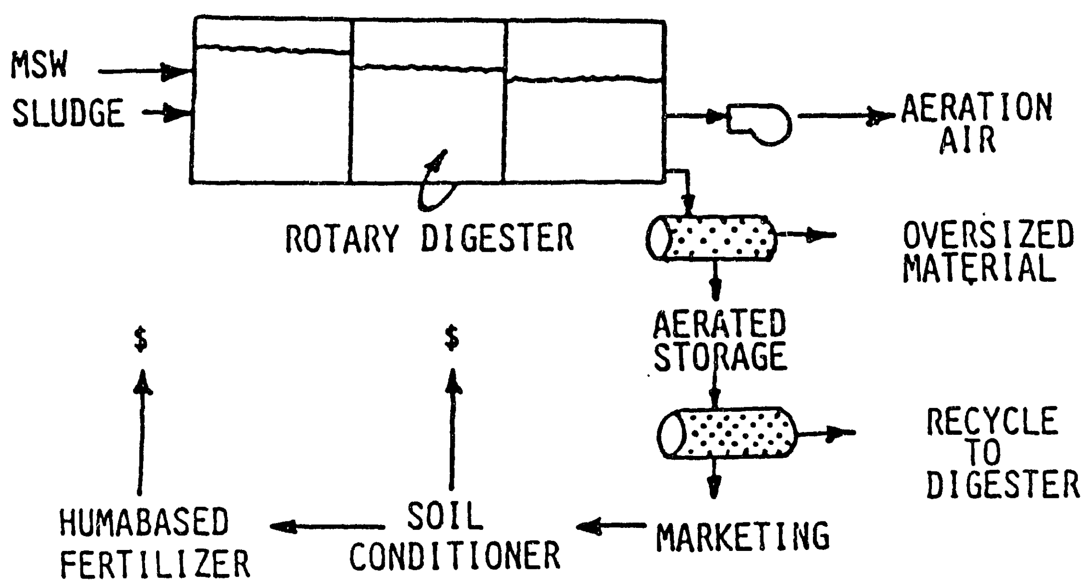

Figure G-6. Co-composting Facility Process, Big Sandy, TX (736)

Optimum operation is with daily loading, and three days in the digester (762). Two transfer doors separate the three chambers, isolating the middle chamber's high temperatures of 71 degrees C from the cooler temperatures in the first and third chambers. After unloading of chamber 3 at the tail end of the digester, material is then transferred from chamber 2 to 3, and from chamber 1 to 2, leaving some material in chamber 1 to inoculate a new load of waste. After three days in the digester (one day in each chamber), chamber 3 is emptied through four sliding doors. The partially composted material is dropped onto a conveyor belt and transported to a trommel screen with 1-inch openings. Trommel oversize material, which is typically 15 percent by volume, is sent to a landfill. Trommel undersize material is then further composted and stabilized for at least 14 days. The piles are turned occasionally by a front-end loader. The compost material is then screened to minus 3/8 inch, with oversize material from the final screening being returned to the digester. Table G-8 presents the heavy metal concentrations of Big Sandy compost compared to New York state standards. Approximately 25 percent of the finished compost is used in university and other research projects.

G.2.2.10.2 Discussion. The Big Sandy composting facility is the longest running MSW composting plant in the U.S. From 1972 through 1977, the facility processed MSW. Following a brief shutdown period, the facility reopened in 1980. Currently, the facility processes agricultural waste, brewery sludge, and sawdust for 40 weeks per year. The remaining 12 weeks each year are spent composting MSW and sewage sludge for demonstration purposes. Compost product sales revenues were approximately $1 million dollars in 1991. Markets include the horticultural and landscaping industries, and turf farms.

TABLE G-8. METAL CONCENTRATIONS OF FINISHED COMPOST[a] FROM BIG SANDY, TX COMPARED TO NY STATE REGULATIONS (741)

	Mean Concentration (n=4) (mg/Kg)	Standard Deviation (mg/Kg)	New York State Class I Regulations[b] (mg/Kg)
Cadmium	4.5	0.377	10
Chromium	46	15.14	1000
Copper	236.75	81.94	1000
Lead	109	80.49	250
Mercury	0.1[c]	–	10
Nickel	31.5	12.39	200
Zinc	481	99.15	2500

[a]Bedminster, 1990

[b]Class I regulations for sewage sludge means unrestricted use of compost

[c]Only one test was done for mercury in 8/90

G.2.2.11 Resource Recovery, Inc. Coffeyville, Kansas

G.2.2.11.1 Process Description. This privately owned and operated composting operation uses a very basic, low technology process to compost MSW (750). Trucks deposit waste directly on the ground in windrows and a custom-made loader attachment runs through the waste to break open bags and mix the material. Mixing is conducted every 2 to 3 days during the approximate 8 week composting period. Composted material is then screened with a 2-inch screen. Screen oversize material is landfilled and screen undersize material is stockpiled until uses for the compost are identified (731).

G.2.2.11.2 Discussion. This operation has kept a low profile and it wasn't until 1991 that any mention of this facility appeared in the literature (741). It is not certain how long composting has been taking place at this facility.

G.2.2.12 Berrien County Resource Recovery Authority, Nashville, Georgia

The only information available in the literature on the Berrien County process is that it uses the Lundell technology (731).

G.2.2.13 TRS Industries Co-Composting Facility, Des Moines, Iowa

G.2.2.13.1 Process Description. TRS Industries operated a pilot project from December 1989 to December 1990, processing 60 tons per day of MSW with 25 TPD of sewage sludge. Full-scale operation started in March 1991 under a 10-year operating contract with the City of Des Moines.

Incoming MSW is hand picked to remove rejects, followed by a trommel with 6-inch screen openings. The trommel oversize material passes by another hand picking station to remove noncompostables such as textiles and plastics. The trommel undersize material enters a secondary trommel with 2-1/2 inch openings to separate grit and other small inorganic matter. The secondary trommel oversize material passes by a third hand picking station to again remove noncompostables before being fed to a custom built vertical shredder. The shredder reduces the particle size to 2 to 4 inches for composting.

Shredded MSW is mixed with sewage sludge (at 25 percent solids content) in a custom built stationary blender at a weight ratio of 3 parts MSW to 2 parts sludge. The mixed material is then taken to the compost pad where windrows 16 feet wide by 7 feet high and 300 feet in length are constructed. The piles are turned with a windrow turning machine, and after 8 weeks of composting, the material is screened with a 3/8-inch trommel. The City of Des Moines has responsibility for marketing the compost under the tradename DMGRO. The Iowa Department of Agriculture has licensed this material for distribution at application rates of 30 dry tons per acre (731).

G.2.2.13.2 **Discussion**. Very little information is available about the Des Moines co-composting facility since it only recently began operation.

G.2.2.14 **Riedel Oregon Compost Company Facility, Portland, Oregon**

G.2.2.14.1 **Process Description**. Figure G-7 depicts the Portland composting facility process. After weighing, waste is deposited inside the receiving and processing building. Large items are removed before the material is pushed into two side-by-side infeed pits. Two parallel processing lines convey waste through a bag opener and into an elevated, climate-controlled hand picking room where plastic bags, recyclables, and hazardous items are removed and dropped through chutes into containers on the ground floor. Recyclable items are taken to a separate section of the building where they are processed for market.

Both conveyors from the picking area feed into a hydraulic ram which pushes waste into two 80 foot long by 12 foot diameter Dano drums. Collected storm water run-off from the 18-acre site is used as the moisture source, with approximately 60 gallons of water added per ton of waste to adjust moisture content in the drum to 55 percent. Waste is tumbled in the drum at four revolutions per minute for 6 to 8 hours, pulverizing the waste. Air is also blown through the drum. Steel posts on the inside wall of the drum serve to break apart waste and minimize material aggregation.

A 6-inch screen is attached to the discharge end of the drum, rotating with the drum. Screen oversize material is landfilled, and screen undersize material drops onto another screen which also rotates with the drum. Plus 2-inch material from this screen is landfilled, and minus 2-inch material passes by a magnet to remove ferrous metals. The resulting stream is conveyed to one of two 54,000 square foot open-sided aeration buildings for composting. The material is spread by a conveyor to a depth of 6 to 8 feet on a floor of slotted aeration blocks through which moisturized air is forced. No turning of the material is planned during the 21 days of composting. The material is then moved by front-end loader to one of two 27,000 square foot maturation buildings for 21 days of curing in static piles.

Final processing includes magnetic separation, screening, air classification, and destoning. Final product size will be either minus 1 inch or 3/8 inch.

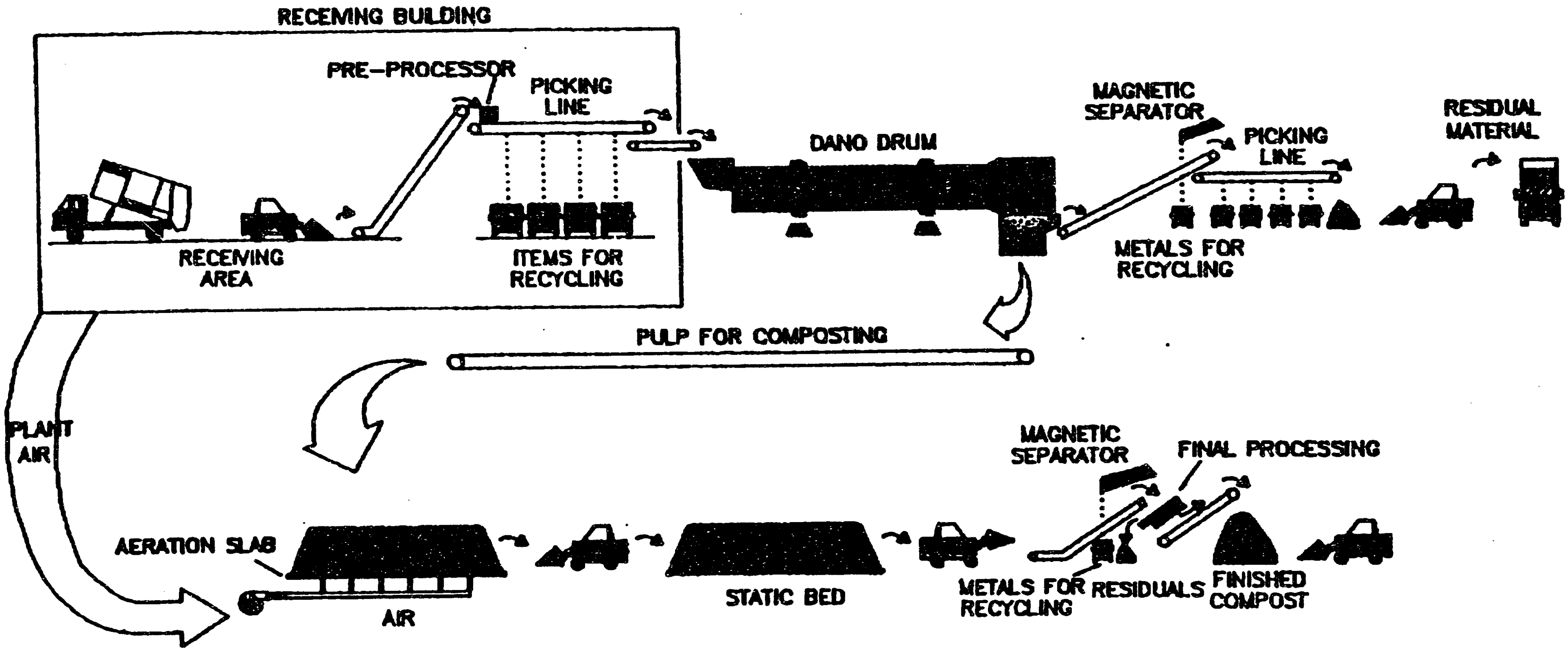

Figure G-7. Riedel/Dano Composting Process (763)

The facility was designed to be operated on two shifts per day with 25 to 30 employees per shift. The operation is monitored from the control room via a closed-circuit television system. A laboratory is also located in the processing building for quality control of the compost product.

G.2.2.14.2 Discussion. For 9 months since its start-up in July 1991, the Portland facility was operated by the Riedel Oregon Compost Company, Inc. During that time, nearly 500 complaints regarding the strong odors allegedly coming from the plant were filed with Oregon's Department of Environmental Quality (DEQ) (907). Riedel was responsible for controlling odors according to its service agreements with the Metropolitan Service District, as well as its DEQ operating permits and financing conditions in its bank note. When Riedel could not pay for the odor abatement equipment valued at $3.5 million, the bank took over operations, stopped receipt of MSW and began the search for a new operator. Of the 80,000 tons of material produced at the plant since start-up, Riedel never sold any of the compost due to poor quality. The material was directed to a nearby landfill for use as a final cover as part of the landfill closure plan.

G.2.2.15 Addington Environmental, Inc. Co-composting Facility, Ashland, Kentucky

Very little information is available about the Ashland facility, but a combination of mechanical and manual sorting was used before shredding waste to a 2-inch particle size for composting. Sewage sludge may also be added. The MSW composting operation was closed a few months after it began operation due to state closure of the local landfill which was accepting the reject material. The high cost of disposing of rejects in a more distant landfill made the continued operation of the facility too expensive. Sludge composting is continuing.

G.2.2.16 Pena-Ayala Company Composting Facility, Edinburg, Texas

Very little information is available about this facility.

G.2.2.17 MSW Composting Facilities in Start-up or Under Construction, July 1991 (667)

Facilities in Start-Up Operation

- Bellingham, Washington - 250 tons per day
- Pembroke Pines, Florida - 660 tons per day
- Martin/Fairbault County (Prairieland), Minnesota- 100 tons per day

Facilities Under Construction

- Lakeside, Arizona- 12 tons per day

- Escambia County, Florida- 400 tons per day
- East Central (Mora), Minnesota- 250 tons per day
- Wright County, Minnesota- 160 tons per day
- Scott/Carver, Minnesota- 200 tons per day
- Council Bluffs, Iowa- 80 tons per day
- Mackinac Island, Michigan- 2,000 tons/year with 400 tons/year sludge
- Kimbering City, Missouri- 75 tons per day with sludge
- Adams County, Wisconsin- 20 tons per day
- Columbia County, Wisconsin- 80 tons per day with sludge

G.3 ENERGY ASSESSMENT

Very little information is available in the literature reviewed regarding MSW composting facility energy usage. Most of the available data is limited to annual costs for utilities and operation and maintenance.

The two primary factors determining energy usage at MSW composting facilities are the type of composting system and the amount of waste processed. Obviously, the more mechanized the facility is the more energy it will consume. Approximately 50 to 70 percent of the energy used in a composting facility is for preparing the material for composting (756). Other energy users include the mechanical separation equipment, blowers, windrow turning machines, pumps, lights, and mobile vehicles (750).

The largest single energy use in a composting facility is in particle size reduction by shredders or rotating drums (756). Energy requirements for reducing the particle size have been shown to increase sharply as increasingly small particle sizes are produced. For example, measurements taken during shredder operation showed that the specific energy (gross energy minus the freewheeling energy divided by the throughput of the material) requirement increased from about 5 kWh per ton to produce approximately a 1-1/2 inch particle size to about 45 kWh per ton for a 1/4 inch particle size (753). Approximately 13.5 kWh per ton is expended to size reduce MSW to a particle size of approximately 1 inch.

Two other large energy users are air classifiers and trommel screens. Energy usage by air classifiers ranges from 3.1 to 3.8 kWh per ton of throughput (756). Energy consumption by trommel screens is approximately 0.7 to 1.0 kWh per ton of materials produced (756).

Table G-9 presents the energy requirements for a 1,320 ton per day MSW and 330 ton per day sewage sludge co-composting facility. It shows the amount of energy consumed at various stages of preprocessing, composting, and postprocessing, as well as miscellaneous aspects such as ventilation. The table shows that an enclosed or in-vessel system uses about 30 kWh to produce a ton of finished compost. In comparison, a turned windrow system requires about 21.8 kWh per ton of compost produced.

TABLE G-9. ENERGY REQUIREMENTS FOR COMPOST PRODUCTION[a] (756)

STAGE		SPECIFIC ENERGY CONSUMPTION (kWh/T MSW) WINDROW TURNED	STATIC	ENCLOSED GENERIC
PREPROCESSING				
MOBILE EQUIPMENT		0.2	0.2	0.0
SIZE REDUCTION		9.1	9.1	9.1
SEGREGATION (AIR CLASSIFIER, MAGNETIC SEPARTOR, TROMMEL, STONER)		4.2	4.2	4.2
CONVEYING		0.5	0.5	0.5
MIXING (REFUSE SLUDGE)		0.6	0.6	0.6
	SUBTOTAL	14.5	14.5	14.4
COMPOSTING				
TURNER		0.2	0.0	0.0
BLOWERS		0.0	4.1	0.0
AERATOR, FEED, DISCHARGE		0.0	0.0	9.1
MOBILE EQUIPMENT		0.2	0.1	0.1
	SUBTOTAL	0.4	4.2	9.2
POSTPROCESSING				
SIZING		5.3	5.3	5.3
CONVEYNG		0.1	0.1	0.1
MOBILE EQUIPMENT		0.2	0.2	0.2
	SUBTOTAL	5.5	5.5	5.5
MISCELLANEOUS				
VENTILATION, LIGHTING		0.9	0.9	0.9
	TOTAL	21.4	25.2	30.0

(a) ADAPTED FROM REFERENCE CITED;
BASED ON 1,320 TPD OF MSW AND 330 TPD SLUDGE.

Regarding the overall environmental impacts of energy usage at MSW composting facilities, an environmental impact statement for an MSW composting facility proposed for Southold, N.Y. concludes that the energy usage would be greater than that for an existing landfill, but that the proposed facility "will not pose a significant impact to the use of energy within the Town of Southold." (728)

A 1989 review of MSW composting in Europe (45) reports annual electrical costs for a 33,000 ton per year MSW and 11,000 tons per year sewage sludge composting plant to be $75,500 (U.S. dollars), assuming electricity costs $0.08 per kWh.

An unpublished annual operating report was reviewed for the Falkenberg, Sweden MSW/sludge co-composting plant. This facility processed 25,517 tons of MSW in 1984 while consuming 435,000 kWh at a cost of $18,940, or 17.05 kWh per ton.

The U.S. Office of Technology Assessment published a 1989 report (463) which presented the estimated costs for a 400 ton per day MSW composting facility. For a windrow composting system, annual utility costs are estimated to be from $280,000 to $430,000. These same costs are estimated at $100,000 to $120,000 per year for an in-vessel composting system.

A 1988 unpublished feasibility study of MSW co-composting for Eastern Rensselaer County, New York (727) estimates the annual electrical costs for a 100 ton per day composting facility to be $70,000 at $0.07 per kWh, and annual fuel costs to be $10,000. These estimates were based on information provided by compost system vendors with operating systems in Europe.

G.4 ECONOMIC ASSESSMENT AND LIMITATIONS

G.4.1 Costs from the Literature

To effectively degrade MSW by the composting process, the waste must be reduced to relatively small particles to expose as much surface area to the micro-organisms that consume the organic material. This step is most commonly accomplished with shredding and grinding equipment, as well as rotating drums that pulverize waste. The particle size reduction step is the most capital-intensive portion of an MSW composting facility (756). The cost of particle size reduction equipment varies with the size and capacity of the machine. Installed costs can be over $1 million for a shredder. Some compost facilities use multiple shredders or hammermills, accounting for a fairly high capital cost.

Operating costs for particle size reduction equipment are also high due to the energy usage, as discussed in Section G.3, and the rate of machine wear (756). Additional pre-processing steps include magnetic separation, screening, air classification, and manual picking to remove inorganic material from the feed stream to be composted. It has been estimated that typical costs for pre-processing MSW range from $15 to $30 per ton of MSW input (756).

The available composting facility capital costs and operation and maintenance (O&M) costs are summarized in Table G-10. Capital costs range from as high as $71,545,000 for the 1000 ton per day Delaware Reclamation Project, to as low as $411,000 for the Lake of the Woods County composting plant. Annual O&M costs range from $30,212,408 at the Delaware facility to $264,769 at Lake of the Woods. The high costs of the Delaware Reclamation Project must be considered in light of the fact that the facility was constructed as a full-scale demonstration plant. The plant includes elaborate subsystems for separating ferrous metals, aluminum, and glass from the feedstock while processing a large quantity of MSW and sewage sludge (1,000 and 350 TPD respectively). Cost information for the private facility at Coffeyville, Kansas was not available, but due to the very low technology used at this outdoor, turned windrow operation, capital and operating costs are probably the lowest of all facilities (750).

Four vendor designed systems are currently under construction in Minnesota. Available data on these facilities are presented in Table G-11.

A 1989 evaluation of the economics of composting in Europe (45) estimated capital costs for a facility with a capacity of 33,000 tons per year of MSW and 11,000 tons per year of sewage sludge to be $5,610,000 in U.S. dollars. The report cites the results of a survey which showed a range of operating costs from $15 to $53 per ton, and offers the following explanation for this range in costs.

> "Variations in costs are caused for example, by the chosen method of preliminary treatment and composting, additional steps of compost processing, disposal of screenings at landfill or incinerators and safety standards and environmental pollution control." (45)

A 1989 report from the U.S. Office of Technology Assessment (463) estimated capital costs for a 400 ton per day MSW composting facility using windrow technology to vary from $7,870,000 to $15,550,000, and a facility using in-vessel composting to range from $4,930,000 to $6,190,000. Capital cost per daily ton of capacity were estimated to range from $12,000 to $39,000. This same report estimated the O&M costs for a 400 ton per day MSW composting system to range from $1,770,000 to $3,430,000 per year, or $17 to $33 per ton. For in-vessel systems the O&M costs were estimated to vary from $2,010,000 to $2,790,000, or $19 to $27 per ton.

TABLE G-10. SUMMARY OF CAPITAL COST DATA FOR SELECTED MSW COMPOSTING FACILITIES IN THE U.S.[1]

#	DESIGNATION	FACILITY LOCATION	CAPACITY (T/D)	CAPITAL COST ($1000)	O & M COST ($1000)	TIPPING FEE ($/T)	
1	DELAWARE RECLAMATION (DSWA)	WILMINGTON, DE	1000	71,500	30,200	45	
2	PORTAGE CO-COMPOSTING	PORTAGE, WI	16	1,000	1,000	-	(2)
3	RECOMP, INC. COMPOSTING	ST. CLOUD, MN	100	7,500	279	76	
4	FILLMORE COUNTY COMPOSTING	PRESTON, MN	18	702	500	70	(3)
5	SUMTER COUNTY COMPOSTING	SUMTERVILLE, FL	50	5,000	NA	50	
6	PENNINGTON COUNTY COMPOSTING	THIEF RIVER FALLS, MN	40	1,300	265	45	
7	LAKE OF THE WOODS COMPOSTING	GRACETON, MN	10	411	256	-	(4)
8	SWIFT COUNTY COMPOSTING	BENSON, MN	25	1,615	NA	68	
9	AGRIPOST, INC. COMPOSTING	DADE COUNTY, FL	350	30,000	300	26	
10	BEDMIN. BIOCONVERSION CO-COMP.	BIG SANDY, TX	25	750	NA	-	(5)
11	RESOURCE RECOVERY, INC.	COFFEYVILLE, KS	80	N/A	NA	15	
12	BERRIEN COUNTY RES. REC. AUTH.	NASHVILLE, GA	20	N/A	NA	NA	
13	TRS INDUSTRIES CO-COMPOSTING	DES MOINES, IA	200	4,200	NA	21.63	
14	RIEDEL OREGON COMPOST	PORTLAND, OR	600	30,000	NA	68	
15	ADDINGTON ENVIRON., INC.	ASHLAND, KY	150	N/A	NA	NA	
16	PENA-AYALA COMPANY	EDINBURG, TX	80	N/A	NA	NA	

NOTES:

(1) ADAPTED FROM TABLE 1
(2) THROUGH TAXES
(3) $35/T IF MSW COMPONENT SEPARATED
(4) SERVICE FEE OF $2.12/HOUSEHOLD/MO.
(5) DEMONSTRATION FACILITY

TABLE G-11. MINNESOTA VENDOR-DESIGNED FACILITIES UNDER CONSTRUCTION (750)

Location	Throughput (TPD)	Capital Cost ($ x 10^6)	Vendor
Prarieland	1	$8.44	OTVD (Seres)
Wright County	160	$13.80	Buhler
East Central	250	$13.44	Daneco
Scott/Carver	200	$13.60	Dano

A 1990 report from the Ontario Ministry of the Environment reports the capital costs of a 132 ton per day in-vessel composting facility in France to be about $1.02 million (U.S. dollars) in the early 1980s, with operating costs approximately $8.50 per ton.

Table G-12 presents capital and operating costs for three MSW composting facilities in Germany which use the Dano drum technology. The capital costs found in the literature for the 220 TPD MSW/sewage sludge co-composting facility in Bad Kreuznach are contradictory, as noted in Table 12. Operating costs are $28 per ton (including reject disposal) at Duisburg, $33 per ton at Bad Kreuznach, and $30-38 per ton (including capitalization, collection, processing and residue disposal) for Aurich.

TABLE G-12. CAPITAL COSTS FOR GERMAN MSW COMPOST FACILITIES (318, 744, 739)

Designation	(T/D)	Capital Cost ($)	O&M Cost ($/T)
Duisburg	20,000	NA	28
Bad Kreuznach	220	16,000,000 (1)	33
Aurich	50,000	7,000,000	30 (2)

(1) Pricetag was $30,000,000 deutsche marks according to Ref. 744. However, Ref. 739 reports $7 million contrasted to the $16 million reported by Ref. 318.

(2) Range of operating costs is $30/T to $38/T.

Unlike waste-to-energy facilities where substantial revenue can be produced by the generation of steam and/or electricity, most composting facilities are not financed on the basis of revenue produced by the compost product. The value received for compost also varies substantially, with some operating U.S. facilities receiving nothing for the compost. The Delaware and St. Cloud facilities report selling compost at $4 - 4.50 per cubic yard (206, 733).

G.4.2 Regional Cost Variables

Any comparison of the capital and O&M costs of composting facilities must consider the effect of both regional variables and the technology utilized at the facilities. Several studies have pointed out the impact of regional conditions on the costs of MSW composting facilities and their operations. BioCycle Journal of Waste Recycling (152) likened the comparison of MSW composting facilities to comparing "apples and oranges", as follows:

> "In general, it is difficult to compare an entire facility with another. There will always be differences in the waste stream and in the role that composting plays in a municipality's overall solid waste management strategy. Additional factors, such as the existence of an aggressive source separation program and targeted end uses for the compost, will affect capital investments, degree of processing at the facility, the quantity of rejects and much more. For now, and probably for the foreseeable future, the MSW composting learning curve will reflect the experiences of each individual composting facility, with direct comparisons being drawn from specific aspects of the projects." (152)

Echoing this need for factoring in regional differences is the report from the Ontario Ministry of the Environment (743), which states in its discussion of the economics of composting,

> "But, other factors make an economic comparison of operating facilities and composting technologies very difficult. For example, local factors such as climate, labor, and equipment are highly variable. Moreover, accounting practices vary since composting projects are frequently public sector operations added to existing wastewater or solid waste operations. Cost items such as land, labor, and equipment needed for composting operations may be shared with other existing operations such that the costs attributed to composting reflect estimated incremental costs rather than actual market values. To complicate matters, the definition of operations and maintenance costs are not precisely consistent. In summary, since the accounting rules used to allocate the cost (and revenues) of public sector composting systems are in many cases arbitrary, the reported results are not always comparable."(743)

G.4.3 Tipping Fees

Table G-10 presents the tipping fees at U.S MSW composting facilities, showing a wide range from a low of $15 per ton at Coffeyville, Kansas to $76 per ton at St. Cloud, Minnesota. Difficulties in comparing tipping fees are illustrated by the Portland, Oregon and Dade County, Florida facilities. Both facilities have capital costs of $30 million, and the design capacities are similar at 600 and 800 TPD, respectively. However, the Portland facility has a tipping fee of $68 per ton while the Dade County facility's was $26 per ton before closing in early 1991. The reasons for the differences in these tipping fees are not explained in the literature, but are known to be influenced by a wide range of variables.

G.4.4 Cost Sensitivity

As previously discussed, the costs of MSW composting facilities vary greatly. Some of the primary factors influencing the costs are discussed herein, particularly the types of waste, waste handling and processing systems, regulations, reject disposal, and finance charges.

G.4.4.1 Waste Type

The types of wastes handled at an MSW composting facility impact its costs in a number of ways. Individual waste types include mixed MSW, source separated MSW, and sewage sludge.

The extent to which the wastes are source separated prior to delivery to the facility has the most effect on the costs. A source-separated waste stream will obviously require less in-plant processing, resulting in lower overall costs. This is illustrated by comparing the capital costs per TPD of facilities receiving source separated materials with that of facilities receiving mixed MSW. The average capital cost per TPD for facilities that could be identified as receiving only source-separated materials is approximately $50/TPD. This same value for facilities receiving mixed MSW is approximately $66/TPD, a 32% increase.

One of the drawbacks of relying on source separation as a pre-processing step is that the effectiveness of this step cannot be controlled. People for many reasons often fail to comply with the presorting requirements resulting in some inorganic material ending up in the compost, and recyclable items being contaminated with organic matter. The literature does not discuss the economic aspects of either compost or recyclables quality reduction at facilities processing a source separated feedstream.

Two examples of facilities where extensive equipment is used to remove inorganics from a mixed MSW waste stream are the Delaware Reclamation Project, and the now-closed Agripost facility in Dade County, Florida. Both facilities are described in detail in Section G.2. Costs for the DRP are difficult to evaluate and compare because the facility is primarily an RDF production plant with compost being one of the side products. In contrast, the Agripost facility's primary goal was to compost MSW. Any evaluation of its costs from strictly a composting viewpoint, therefore, can be easily construed.

The capital cost for the Agripost facility expressed on a per TPD basis is approximately $85,700. By comparison, the capital cost of the Fillmore County, Minnesota facility, expressed on a per TPD basis, is approximately $39,000. Operating and maintenance costs were not available for the Agripost facilty.

Facilities co-composting MSW and sewage sludge typically include receiving areas for the sludge, perhaps a sludge dewatering system, as well as mixing devices for blending the sludge with the MSW. The primary economic advantage of co-composting MSW and sewage sludge is the revenue which is generated if tipping fees are charged. An additional cost benefit can be realized in that sewage sludge can provide the moisture often required for MSW composting. Purchase of water from a municipal source or operating an on-site source can perhaps be eliminated. Also, since sewage sludge consists primarily of water which is readily absorbed by MSW, some "in-vessel" composting systems can readily accommodate substantial amounts of sludge.

No information is offered in the literature concerning the economic impacts of using sludge/septage as a source of nitrogen for MSW composting. MSW is commonly deficient in nitrogen, and many facilities that do not co-compost sewage sludge or manures and MSW, purchase a supplemental nitrogen source such as urea.

G.4.4.2 Compost Market Requirements

Another reason that a composting facility could be designed with a lower technology process train is if the primary market for the compost does not require a high quality compost product (45). This is the case at Lake of the Woods (733) and Portage (206) where the intended use of the compost is for landfill cover and therefore inert material is acceptable in the compost. In addition to lower capital costs, one European study documented substantially lower operating costs where no presorting at the facility is required (45).

G.4.4.3 Collection and Hauling Costs

A complete overall evaluation of a project's economics should include the costs associated with collecting and hauling the feed material to the facility. Very little information is available on the increased costs of collecting source separated organic materials, particularly compared to a mixed waste collection system which relies on separation at the composting facility. Several projects are underway in Canada and Europe (744, 729) to evaluate the costs of collecting source separated organic material.

G.4.4.4 Compost Regulations

Only six states have MSW compost regulations in effect as of July 1991: New York, New Hampshire, Florida, Minnesota, Maine, and Iowa (732, 754). A number of other states are in the process of developing regulations. No federal regulations currently exist for MSW composting processes or products, although the U.S. EPA is in the process of developing regulations for use of wastewater sludges (40 CFR 503), including composted sludge, which would apply to MSW compost produced with sewage sludge and septage.

The literature reviewed does not discuss the impact of regulations on the economics of MSW composting. However, it is clear that more stringent regulatory requirements will increase the cost of MSW composting just as environmental regulations have increased costs of landfilling and incineration (750).

A potential regulatory requirement that can significantly affect a project's economics is "best available control technology" for treatment of air emissions, which might involve expensive scrubbers and/or incineration systems. Requirements to manage leachate could result in covered areas to keep precipitation from reaching the compost, collection systems for leachate, disposal of leachate in wastewater treatment facilities, or on-site treatment of leachate.

Another potentially costly regulatory item involves meeting limits on the amount of inert matter allowable in the compost. Costly sorting and screening equipment may be necessary to achieve such limits.

G.4.4.5 Other Cost Issues

One of the more costly aspects of MSW composting is landfill disposal of the processing residuals (756). The percentage of reject material produced by MSW composting facilities varies from about 5 percent at the Agripost Dade County plant, to as much as 45 percent (projected) at the proposed facility for Scott/Carver County, Minnesota (724).

The cost for reject material disposal also varies substantially from region to region depending on the local costs for landfilling. This cost can be minimal where the composting facility owner/operator also owns a landfill, such as at the Lake of the Woods and Portage facilities (206, 733).

Another influence on facility costs is state and federal grant or low interest loan subsidies. For example, Minnesota's capital assistance program provides 50 percent of capital costs, or up to $2 million for publicly owned MSW composting facilities (724).

G.5 INTEGRATION INTO OVERALL WASTE MANAGEMENT STRATEGIES

G.5.1 Regional Impacts

Integration of municipal solid waste composting into overall waste management systems in the U.S. is occurring at a rapid rate, as evidenced by the number of new facilities coming on line in the 1990s (761, 756). As of November 1990, BioCycle Journal of Waste Recycling (751) listed 89 projects in various phases of development, and estimated that by early 1992 there may be 25 operating facilities (207). One survey of 165 solid waste managers determined that nearly 40 percent will include composting as an element of their solid waste management plans (125). The U.S. EPA's 1989 "Decision Maker's Guide to Solid Waste Management" (297) describes this integration as follows.

> "Municipal solid waste composting operations can effectively be combined with recycling programs and/or the preparation of refuse-derived fuels. The processing technologies used separate a compostable fraction, a fraction of materials suitable for recycling, and a stream that can be processed further into RDF. As these technologies develop, the benefit of combining all three operations is expected to become even more attractive."

The analysis of U.S. operating facilities presented in Section 2 shows that four facilities produce RDF: Delaware, St. Cloud, Pennington, and Berrien.

The Solid Waste Composting Council, an organization established in 1990 by compost producers, system vendors, academics and others, expressed this opinion regarding integration with waste-to-energy facilities in one of their issue papers (738):

> "In a properly integrated waste management system, composting should not pose a threat either to recycling or to waste-to-energy operations. The things which are best for composting (food scraps, plant matter, etc.) are precisely those which have the least value for incineration. Organic substances contain high concentrations of water that vastly reduce the efficiency with which waste can be converted into energy."

Such integration seems to be the direction in which at least three Recomp composting projects are going. Recomp's St. Cloud composting facility is currently operated to provide RDF to a waste-to-energy facility. By the fall of 1991, Recomp is expected to have a 250 TPD composting facility operating in Bellingham, Washington in conjunction with a combustion facility; and, Recomp is also part of a consortium of companies proposing to construct an MSW composting facility to work in tandem with a waste-to-energy facility in Rutland, Vermont (750).

G.5.2 Recycling

The Solid Waste Composting Council addressed integration of recycling and composting in an issue paper (738) by pointing out that the EPA and many states use a hierarchy of waste management which includes composting as a type of recycling, second to source reduction, and ahead of incineration, and finally landfill. As presented in the description of operating facilities (Section G.2), recycling is being conducted in conjunction with virtually all facilities through source separation, sorting at the facility, or both.

It is widely recognized in the literature that source separation of recyclables is very compatible with MSW composting (735, 759, 742, 737). Although there is very little information on the impact of source separation of recyclables on compost quality, one article states that a "virtually indisputable" thesis is that "the more complete the separation, the better the compost product will be." (735)

The Cornell Waste Management Institute's opinion (742) of source separation recycling and compost quality is as follows.

> "To produce a safe, marketable compost from MSW, extensive preprocessing is required. The most sensible way to pre-process organic waste is with a comprehensive metal, glass, and plastic recycling program combined with separate household hazardous waste collection." (742)

Limited data presented in the Ontario Ministry of the Environment's 1990 compost literature survey (743) shows that concentrations of heavy metals in compost from source separated MSW "are much lower than those from the other MSW composts presented."

One issue which is generating some discussion in the literature is if paper should be recycled or composted. The Cornell Waste Management Institute makes the case that the current shortage of newspaper mill recycling capacity is only temporary and that a higher form of recycling newspaper is to process it into paper rather than compost, and therefore composting of newspaper should be a temporary solution (742). The Solid Waste Composting Council, while agreeing that paper should be recycled unless contaminated with food or garbage, takes the position that "recycling is neither better nor higher than composting" and that where recycling is not practical, paper should be composted (738).

It is clear from the literature that source separated recycling programs should be implemented with MSW composting since they reduce the operating costs associated with separating inorganics at the facility, and compost quality is improved.

G.5.3 Costs

One reason for the increased interest in MSW composting is that engineering feasibility studies and regional solid waste management plans are concluding that for a major portion of the MSW stream, composting can be less costly than incineration and landfilling (727). An assessment of the role of composting in Connecticut attributes interest in composting in part to the fact that the "cost of composting today is now, on the average, less than other forms of waste disposal" (737). That report also credits more stringent regulations pertaining to landfills and incineration with increasing the costs of those alternatives, thus making composting more cost competitive.

G.5.4 Public Acceptance and Environmental Regulations

For numerous reasons, MSW composting is viewed favorably by many solid waste planners (153, 388, 261, 757). The Housatonic Valley Association's 1991 assessment of the role of MSW composting for Connecticut attributes some of the renewed interest in composting to a growing public awareness of the need to protect the environment and preserve resources (737).

> "More state governments are enacting recycling laws and banning certain "reusables" from landfills. Composting is a reuse strategy whereby wastes disposed of can [potentially] be processed into a usable product that has the potential to be more environmentally acceptable."

The report also cites public concerns regarding air emissions of dioxins and furans from incinerators, as well as concern over heavy metal concentrations in incinerator ash, for stronger public resistance to new and expanded incinerators.

One article attributes the "positive climate" for composting in Minnesota to the following: increased landfill tipping fees; enactment of the state Waste Management Act of 1980; the availability of up to $2 million in state matching grants; the anti-incineration backlash which followed the development of many waste-to-energy facilities in the state; the MSW research projects in Wisconsin; and promulgation of state composting regulations (724).

In 1991, two nationwide environmental organizations, the Environmental Defense Fund and the Environmental Action Foundation, issued position papers opposing mixed MSW composting due to concerns over the quality of compost produced and potential conflicts with recycling. An article that summarized the various positions compared this environmental scrutiny to issues being raised about incineration (726).

> "They include public health and environmental impacts of the process [composting], the products (compost and recyclables), and the residual material. The debate also is firmly rooted in a somewhat philosophical consideration of the degree to which source separation should be involved in solid waste management.

The lack of federal and in most cases, state regulations for MSW compost has also concerned some people, with some communities deciding not to invest in MSW composting until such regulations are in place.

G.6 TECHNOLOGY ADVANTAGES AND DISADVANTAGES

As documented herein, increasing numbers of communities are in the process of developing composting facilities for a wide variety of reasons. Although composting is viewed by many as having substantial advantages over other technologies, there are a number of disadvantages as well.

G.6.1 Advantages

- Composting produces a product that is considered recyclable under State planning criteria, and may therefore be preferred over other approaches to municipal solid waste management (738).

- Composting has the potential for lower capital and operating systems costs than those for other MSW management alternatives based on that portion of the MSW stream most effectively addressed by composting.

- Composting may be more publicly acceptable than a facility using a waste-to-energy technology; although they are not directly comparable alternatives.

- MSW can be co-composted with sewage sludge to mutual advantage.

- Landfill requirements can be minimized if the compost product can be fully marketed.

- The compost product can be used as a landfill cover material.

- The compost product can be landfilled as a last resort, providing a significant volume reduction at the landfill over landfilling of MSW.

- Use of compost can help reduce soil erosion.

- Compost can play an important role in land reclamation and in the rejuvenation of salt-damaged soil along roadways (738).

- Use of compost has the potential to replace the use of peat moss in some applications and thereby reduce the environmental impacts associated with mining peat from wetlands (738).

- Use of compost can increase the germination percentage of seedlings, improve the yield and quality of crops when used in combination with fertilizers, and diminish the need for chemical fertilizers and pesticides (738, 761, 741).

- Replacement of chemical fertilizers with organic fertilizer and compost can reduce pollution of groundwater and surface water (738).

- Compost can suppress plant diseases (738, 761).

- Compost has been shown to improve physical qualities of soil such as porosity, water holding capacity, and bulk density (741).

- The use of compost as a growth media for ornamental plants has been found to be more economical than traditional growing media of peat, sand and vermiculite (757).

- Solid waste compost has twice the water holding capacity of sludge compost (125).

G.6.2 Disadvantages

- The commercial systems available in the U.S. are relatively undeveloped.

- In order to avoid excessive shipping costs, a local market must be developed.

- It is difficult to obtain a long-term sales agreement for the compost product.

- Longer process time is required for MSW composting than for non-biological waste disposal methods.

- Caution must be taken to avoid toxics and heavy metals in the compost feedstock.

- MSW compost systems require several large, complex process equipment items for both front-end and post-processing.

- Compost facilities have large land requirements.

- Obnoxious odors may be produced during the composting process (907).

- Poor quality compost can contaminate soil, water, plants, and animals (733).

- o Application of compost which is not sufficiently mature can have adverse impacts on plant growth (741, 733).

- o Compost has minimal nutrient value (125).

- o Mixed waste composting systems may constrain opportunities for recycling of paper into other paper products if that paper goes to the composting facility (733, 742, 726).

G.7 INFORMATION/RESEARCH NEEDS

This section provides a referenced listing of some of the research needs that have been noted in the literature. Although by no means exhaustive, it highlights the need for further basic research as communities proceed with the implementation of demonstration and full-scale composting systems geared to their specific needs.

G.7.1 Facility Design/Operation

- o Research and develop federal standards for MSW compost facility design, operation and product use to set minimal standards for state regulations (733).

- o Odor prevention, rather than control, by balancing the nutrition of microflora is an important area of operation and process research. Research involves respirometry and spectroscopic analysis (377).

- o Improve efficiency of mechanical recovery of recyclables (463, 733).

- o Reduce materials handling problems (463).
- o Identify mechanics of composting source separated organics such as food waste and paper waste, especially mixing ratios (377).

- o Identify convenient and inexpensive collection programs for food waste.

- o Establish the relationship between various feedstock components making up the MSW compost and the ultimate chemical content of the compost product (752).

- o Evaluate the impact on compost quality of different composting systems (733, 754).

- o Further identify the opportunities for integrating MSW composting with incineration.

G.7.2 Compost Markets

- o A scientifically based universal standard should be determined and established for MSW composts at the Federal level (752).

- o Establish standards for agronomic and public acceptance for MSW composts (752).

- o Provide information on the comparative qualities of composts of different feedstock materials, or mixes of different feedstock materials, to determine if differences exist that may affect use (377).

- o A standard test for compost maturity and stability should be developed (377, 752).

- o Identify appropriate tests and standards for the end products of mixed waste composting (733).

- o Determine how much of the variability in heavy metal levels in different sub-samples of a given compost is due to inadequate sampling protocol, and how much is due to the inherent variability of the compost feedstocks (752).

- o Determine if variable metal levels among sub-samples of a given MSW compost product make any significant differences in plant growth response (752).

- o Determine the impact of household hazardous waste diversion programs on compost quality.

- o Analyze and compare the MSW uses from operating facilities.

G.7.3 Environmental Impacts

- o Identify the probability that compost will be used for the specific use it was designed for, and what are the risks if its intended use is not its actual use (733).

- Identify contingency plans for environmental and health impacts if precautions in operating procedures and material processing fail (733).

- Identify methods of handling contaminated end product (733).

- Identify fate of pesticides at 50 to 65 degrees C, and other volatile compounds (377).

- Determine bioavailability of metals and organics in MSW composts compared to sludge composts (752).

- Determine extent of degradation and/or immobilization of potential toxic metals and organics that may occur during microbial decomposition.

- Characterize the quality of leachate from different composts (377).

- Identify impacts of compost use on the ecosystem (wildlife, plant communities) (377).

- Identify long-term effects of compost to soils with prolonged use of composts, and the fate of contaminants. (752).

- Identify overall environmental impacts of source separated composting and non-source separated composting (726).

- Determine the occupational health and safety risks at composting facilities, particularly noise, airborne bacteria, contact with waste materials, and equipment operation hazards (733).

- Evaluate odor control and management at all phases of the composting process.

- Determine reliable sample collection procedures.

G.7.4 Costs

- Identify overall costs of source separated composting and non source separated composting (726).

- Quantify the energy impacts of using compost as a replacement for topsoil, chemical fertilizer, peat moss, herbicides, and pesticides.

- Evaluate the impact on facility capital and operating costs from source separation of organic wastes.

- Evaluate the cost impact of using "best available control technology" to control odors from composting facilities.

G.7.5 Public Acceptability

- Determine the optimal integration of composting with recycling programs (733).

- Determine the optimal compost facility design for minimizing environmental and health impacts (733).

- Document successful MSW composting facilities in other countries.

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Document Control Page	1. NREL Report No.	2. NTIS Accession No.	3. Recipient's Accession No.
	NREL/TP-431-4988I	DE92016433	

4. Title and Subtitle Data Summary of Municipal Solid Waste Management Alternatives. Volume IX: Appendix G—Composting	5. Publication Date October 1992 6.
7. Author(s) SRI International	8. Performing Organization Rept. No.
9. Performing Organization Name and Address SRI International 333 Ravenswood Ave. Menlo Park, CA 94025-3493	10. Project/Task/Work Unit No. WM21.1010 11. Contract (C) or Grant (G) No. (C) RF-1-11003 (G)
12. Sponsoring Organization Name and Address National Renewable Energy Laboratory 1617 Cole Blvd. Golden, CO 80401	13. Type of Report & Period Covered Subcontract Report 14.

15. Supplementary Notes

NREL Technical Monitor: Bimleshwar Gupta and Philip Shepherd (303) 231-1760

16. Abstract (Limit: 200 words)

The overall objective of the study in this report was to gather data on waste management technologies to allow comparison of various alternatives for managing municipal solid waste (MSW). The specific objectives of the study were to:

1. Compile detailed data for existing waste management technologies on costs, environmental releases, energy requirements and production, and coproducts such as recycled materials and compost.
2. Identify missing information necessary to make energy, economic, and environmental comparisons of various MSW management technologies, and define needed research that could enhance the usefulness of the technology.
3. Develop a data base that can be used to identify the technology that best meets specific criteria defined by a user of the data base.

Volume I contains the report text. Volume II contains supporting exhibits. Volumes III through X are appendices, each addressing a specific MSW management technology. Volumes XI and XII contain project bibliographies.

17. Document Analysis

a. Descriptors

municipal waste; waste to energy; resource recovery; recycling

b. Identifiers/Open-Ended Terms

c. UC Categories

249

18. Availability Statement National Technical Information Service U.S. Department of Commerce 5285 Port Royal Road Springfield, VA 22161	19. No. of Pages 64 20. Price A04

Form No. 0069E (6-30-87)

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DATE FILMED

5/11/93