United States
Environmental Protection
Agency

Solid Waste and
Emergency Response
(5306)

Policy, Planning
and Evaluation
(2121)

EPA/530-SW-90-073A

November 1993

NTIS: PB94-100 138

EPA

Markets for Compost

Printed with soy/canola ink on paper that contains at least 50 percent recycled fiber.

DISCLAIMER

The mention of commercial products or composting vendor systems in this report does not indicate endorsement or approval of use by the U.S. Environmental Protection Agency.

MARKETS FOR COMPOST

Project Manager:
Richard M. Kashmanian, Ph.D.
OFFICE OF POLICY, PLANNING AND EVALUATION

OFFICE OF SOLID WASTE AND EMERGENCY RESPONSE

U.S. ENVIRONMENTAL PROTECTION AGENCY

November 1993

ACKNOWLEDGEMENTS

This report was prepared under U.S. Environmental Protection Agency Contract Nos. 68-01-7310 and 68-C8-0036, at the direction of Richard Kashmanian, EPA Work Assignment Manager. It was prepared in conjunction with CalRecovery, Inc. and Franklin Associates, Ltd. The study benefitted from comments by EPA's Hope Pillsbury, Truett DeGeare, Robert Dellinger, and Terry Grogan, from the Office of Solid Waste and Emergency Response.

EPA would also like to acknowledge the assistance of the following reviewers, who commented on previous drafts of this document and provided suggestions for improvements. These individuals include:

Pegi Ballister-Howells	Scat Engineering
Patrick Kennedy	Alternate Disposal Systems, Inc.; and American Soil, Inc.
Geoffrey Kuter	International Process Systems, Inc.
John McCabe	Michigan Department of Natural Resources
Percival Miller	New York Legislative Commission on Solid Waste Management
Nancy Vandenberg	Markets for Recycled Products
N.C. Vasuki	Delaware Solid Waste Authority

FOREWORD

The status of composting as a method of managing leaves, grass clippings, brush, and other municipal organic materials is changing rapidly. New programs continue to be implemented.

This compost market study was conducted primarily during the Fall of 1989. At that time, there were 651 yard trimmings composting facilities i.n the U.S. There were over 1,400 and 2,200 of these facilities in 1990 and 1991, respectively, and nearly 3,000 at the end of 1992. Growth also took place in municipal solid waste composting, with the number of operational programs increasing from 7 in 1989 to 18 in 1991 and 21 in 1992. Furthermore, the number of States that have established landfill disposal bans for some or all components of their yard trimmings jumped from 10 in 1989 to 17 in 1991, 22 in 1992, and 23 by mid-1993. The States added to the list are Arkansas, Georgia, Indiana, Maryland, Massachusetts, Maine, Michigan, Missouri, Nebraska, New Hampshire, South Carolina, South Dakota, and West Virginia. Tables A and B summarize the status of composting programs as of 1991 are provided as part of this foreword.

Although the basic principles of compostinq remain unchanqed, the types of technologies employed and, ‘more importantly to this report, the market development tools utilized have evolved significantly. Again, the reader is reminded that the research for this report was primarily conducted in 1989. Although some of the facts may not be current, particularly with regard to the individual program descriptions, the concepts presented are still accurate.

TABLE OF CONTENTS

Chapter 3 - COMPOST USES AND MARKETS

Chapter 4 - FACTORS PERTINENT TO DEVELOPING COMPOST MARKETS

Appendix A - EXAMPLES OF EXISTING PROGRAMS AND MARKETS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

INTRODUCTION

Reducing the volume of municipal solid waste (MSW) that must be disposed of is a priority for many communities around the country. Generally, MSW generation is increasing while landfill disposal capacity is decreasing and new landfills are becoming more difficult and expensive to site. The U.S. Environmental Protection Agency (EPA) established a national goal of reducing the MSW requiring disposal by 25 percent through source reduction and recycling (including composting) as a means of reducing the nation's dependence on landfills. Composting the organic portions of the MSW stream is one management technique that is being employed to help attain the EPA goal.

Composting is a biological process of stabilizing organic matter under controlled conditions into a product that is rich in humus and provides organic matter and nutrients. The composting process achieves both volume and weight reduction. Composting can divert yard trimmings (including leaves, grass clippings, and brush), 'food scraps (from residential, commercial, institutional, and industrial sources) , and other easily decomposable organic materials from disposal facilities and convert them into valuable soil amendment products. Therefore, composting can conserve considerable landfill space, save on MSW disposal costs, and produce useful end products. However, as composting activity expands, there also needs to be greater attention to stimulating markets for compost in order to avoid possible oversupplies of compost. This is particularly important as markets for compost become more competitive with increased composting activity.

A key element in designing a market development strategy for compost is to determine the quantity of the product which will be available. However, there is currently a lack of accurate information nationally from which to draw firm conclusions. Data is sketchy for determining the percent contribution of leaves, grass clippings, brush, etc. to the total amount of yard trimmings generated, the current and projected composting levels and compost supplies, the future quality of the compost product, etc.

The greatest potential uses for compost products in a given locale depend on the identified local markets. Therefore, the compost products offered should be designed to meet the quality specifications and quantity demands of the intended markets. There is, therefore, no single "best" compost product.

Likewise, there is no single "best" compost market. Markets for compost must be identified and developed since the economics of composting improve with demand for the finished product. If little or no demand exists for the compost, the cost of storage increases and disposal costs may be incurred. Primary markets have been municipal applications and use by local residents. If increased amounts of compost are to be produced, additional markets must be secured.

The objective of this study is to provide information to expand markets for compost. The information will be useful to producers, marketers, and users of compost, as well as to all levels of government officials.

The study is based primarily on a review in 1989 of the appropriate literature and information obtained from informal discussions with compost marketing experts, compost users, and potential compost users. The nationwide compost market study was conducted on a regional basis, as shown in Figure ES-1. The definition of the six regions defined was not based on size in terms of land area. Rather, criteria such as MSW management activities and characteristics, geographic region, and population density were considered in determining the regions.

EXISTING COMPOST PROGRAMS AND MARKETS

Yard Trimmings composting

composting yard trimmings has been practiced for many years in the U.S. However, this practice has attained a much greater popularity recently. Although the quantities of yard trimmings generated vary from region to region, their contribution to a community's solid waste stream is significant. At the national level, yard trimmings contribute approximately 20 percent annually to the MSW stream. The relative ease with which yard trimmings can be source separated and diverted from landfills has prompted hundreds of yard trimmings composting programs to be implemented in the United States. Many different approaches have been taken in these composting programs, from low-technology to high-technology composting.

Table ES-1 presents certain characteristics of the six study regions. The data in the table show that there seems to be a rough correlation between the tipping fee for landfill disposal and the number of operational composting programs.

The results of the assessment of existing composting programs and markets show that there is a considerable interest in composting, driven primarily by landfill capacity pressures and the consequent need to reduce the amount of materials disposed of. The markets for the finished products vary from uses by public entities, to wholesale and retail sale, to private individuals and residents, to commercial markets. The majority of the existing programs have found adequate markets for the volumes of compost currently produced.

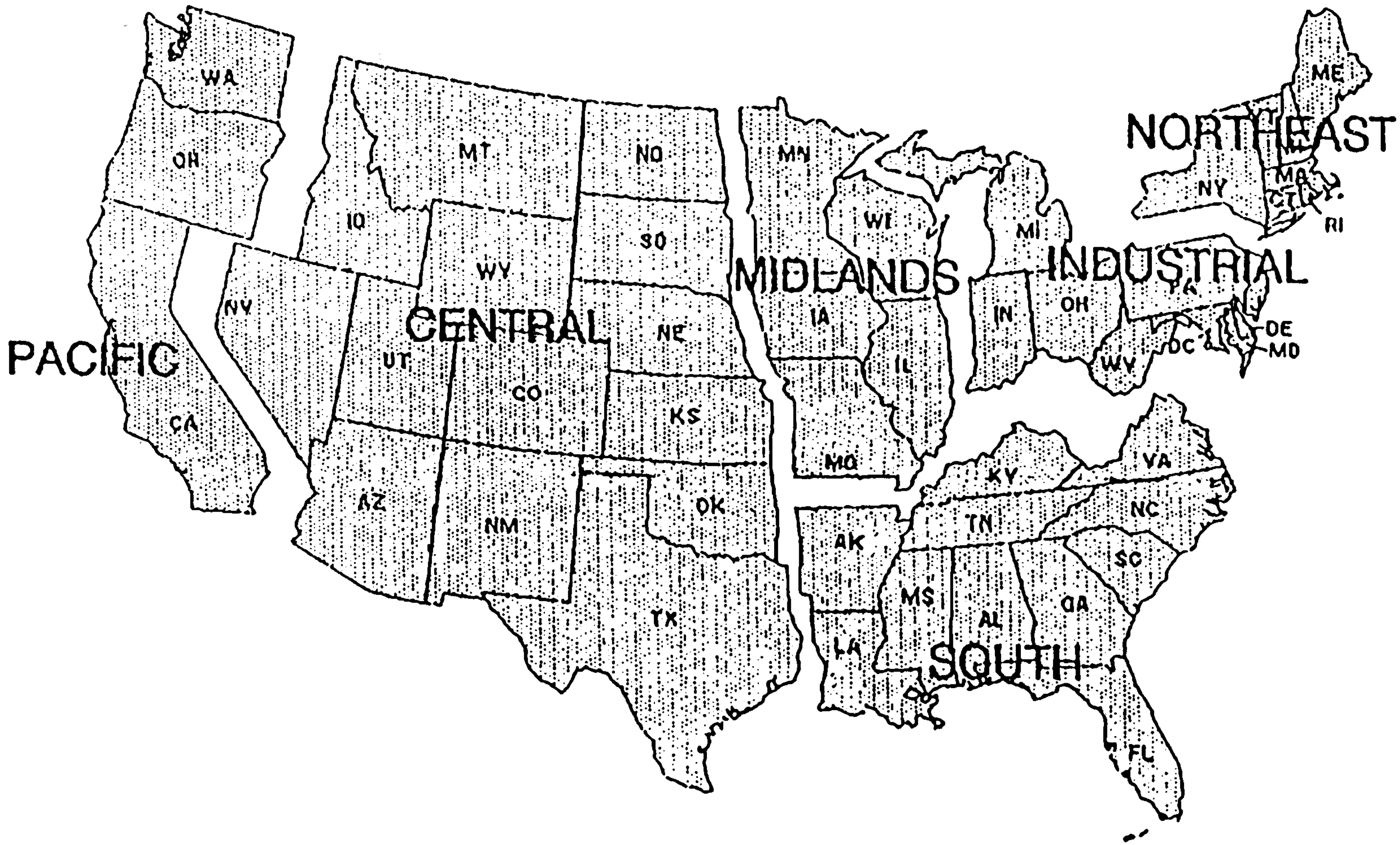

Figure ES-1. Regions of the United States as defined for the study.

Table ES-1

CHARACTERISTICS OF THE SIX STUDY REGIONS

	Central	Industrial	Midlands	Northeast	Pacific	South
Number of States	14	8	5	7	3	11
Population in 1987 (millions)	39	52	29	31	35	56
Population density (population/square mile)	26	235	91	278	110	110
Average landfill tipping fee ($/ton) 1/	9	28	20	58	29	14
Number of yard trimmings composting programs	7	354	135	134	15	5
Number of operational MSW composting programs	0	1	4	0	1	1
List of States	AZ	DE	IL	CT	CA	AL
	CO	IN	IA	ME	OR	AR
	ID	MD	MN	MA	WA	FL
	KS	MI	MO	NH		GA
	MT	NJ	WI	NY		KY
	NE	OH		RI		LA
	NV	PA		VT		MS
	NM	WV				NC
	ND					SC
	OK					TN
	SD					VA
	TX					
	UT					
	WY					

(continued)

Table ES-1 (cont.)

1/ Average of tipping fees reported in Pettit, C.L. "Tip Fees Up More Than 30% in Annual NSWMA Survey." Waste Age, pp. 101-106. March 1989.

Sources: Glenn, J. and D. Riggle. "Where Does the Waste Go? -- Part I." Biocycle. 30(4):34-39. April 1989.

Goldstein, N. "Solid Waste Composting in the U.S." BioCycle. 30(11):32-37. November 1989.

Municipal Solid Waste Composting

Following a decline in interest in MSW composting in the U.S. during the 1960s, it is currently receiving a substantial amount of attention for reasons similar to the growth in yard trimmings composting. This type of composting is typically more capital intensive than yard trimmings Composting, and is capable of composting these materials with food scraps, and non-recycled paper.

Composting source separated MSW refers to the processing of only organic materials suitable for composting which have been segregated at the point of generation. Mixed MSW composting involves the processing of the entire MSW stream without separation at the point of generation, but rather separation at the composting facility with varying degrees of effectiveness. The type of collection system selected should consider and carefully balance costs and equipment needs for collection as well as processing, quality, marketability, and value of the recovered products (i.e., compost and recyclable), total diversion rates from disposal facilities, the public perception toward composting and recycling, etc.

Table ES-2 outlines the status of MSW composting by region. The seven full-scale MSW composting facilities in operation in the U.S. as of Fall 1989 are listed in Table ES-3. Capacities of the facilities range from about ten to a few hundred tons per day. Very little detailed information is available on the quantity or quality of the finished compost. Their output of compost has not been sufficient to permit a long-term definition of the market for their respective products.

CHARACTERISTICS AND BENEFITS OF COMPOST

Compost is a valuable soil amendment. Some of the improvements in soil properties that can result from using compost are:

- improved soil porosity;
- improved water retention;
- improved soil infiltration;
- improved resistance to erosion;
- enhanced storage and release of nutrients;
- decreased soil crusting;
- improved soil tilth; and
- plant disease suppression.

Due mainly to its organic matter and humus content, compost helps to reduce erosion and improve plant growth, which can substantially reduce nutrient transport in runoff to surface waters. Therefore, the addition of compost to soil not only

Table ES-2

STATUS OF MSW COMPOSTING/CO-COMPOSTING FACILITIES IN THE U.S. (FALL 1989)

Region	**Consideration**	**Planning 1/**	**Operational**	**Total**
Central	0	4	0	4
Industrial	3	4	1	8
Midlands	10	16	4	30
Northeast	7	8	0	15
Pacific	2	3	1	6
South	4	6	1	11
Totals	26	41	7	74

1/ Includes planning, design, permitting, and construction stages, as well as pilot-scale or research facilities.

Source: Goldstein, N. "Solid Waste Composting in the U.S." BioCycle, 30(11) :32-37. November 1989.

Table ES-3

OPERATIONAL MSW COMPOsTING/CO-COMPOsTING FACILITIES IN THE U.S. (FALL 1989)

Location	Type of System	Material Added to MSW
Delaware		
Wilmington	In-vessel	Biosolids
Florida		
Sumter County	Windrow	None
Minnesota		
Fillmore County	Windrow	None
Lake of the Woods County	Windrow	None
St. Cloud	In-vessel/drum	Biosolids
Washington		
Skamania County	Windrow	None
Wisconsin		
Portage	In-vessel/drum	Biosolids

Source: Goldstein, N. and B. Spencer. "Solid Waste composting Facilities ." BioCycle, 31(1) :36-39. January 1990.

reduces erosion and recycles nutrients, but also can provide important water quality benefits.

Compost usually does not contain nutrients in amounts necessary to be a one-for-one substitute for inorganic fertilizer due to its generally low content of the macronutrients: nitrogen, phosphorus, and potassium (NPK) . However, it has the advantage of releasing nutrients slowly to plants so that the nutrients may be used over a period of years; therefore, annual applications of compost can build up nutrient reserves. Precautions should be taken so that build-up of excessive levels of nutrients or unwanted substances does not also occur. Compost also can be a good source of micronutrients which plants likewise need, but in smaller amounts compared to macronutrients.

Some composts exhibit plant disease suppression traits by reducing the incidence of certain plant diseases which can plague the nursery industry, for example. This can lead to the reduced use of fungicides for fighting plant diseases.

Feedstocks for composting may exhibit high carbon-to-nitrogen ratios, but these will generally be lowered to a suitable range during the composting process. The composting process is relatively insensitive to the pH of feedstocks, and stable, cured compost tends to have a pH around neutral.

Tests performed on yard trimmings compost indicate heavy metals are not normally a concern. Depending on the quality of the feedstocks and the degree of materials separation performed, mixed MSW compost may contain heavy metals above levels acceptable under current regulations.

Herbicides, pesticides, and other potential toxics are generally not a concern with yard trimmings compost. Tests performed have tended to find these to be within acceptable levels. Toxic organics diminish over time during the composting process. Pesticides that may be present in grass clippings also undergo a dilution effect when grass clippings are mixed with leaves and other organic materials.

A properly maintained composting process should eliminate dangers of pathogens. Temperatures maintained at 55 degrees Celsius for three days ensure adequate pathogen destruction for in-vessel and aerated static pile composting methods. Using the windrow composting method, temperatures must attain at least 55 degrees Celsius over at least 15 days, with a minimum of five turnings during the high temperature period to ensure adequate pathogen destruction. Periodic turning and mixing is important to assure all materials are subjected to such temperatures to achieve pathogen destruction throughout the compost.

Soluble salts should be tested for in composts, since high salinity can adversely affect plants and crops, especially seedlings. Tests performed have generally found total soluble salt concentrations to be at safe levels, which would not be harmful to plants.

CHARACTERISTICS AND BENEFITS OF COMPETING/COMPLEMENTARY PRODUCTS

The competing/complementary products that have been identified are listed in Table ES-4. They have a long history of use in agriculture, horticulture, construct ion, landscaping, and residential gardening. Some of the uses of these products include:

- soil amendment;
- soil aeration;
- moisture retention;
- soil stabilization;
- erosion control and repair;
- growing medium;
- decorative cover; and
- land reclamation.

The prices of competing/complementary products vary depending upon location, availability, and season.

The nutrient content of the competing products is generally low, but these products may be fortified with additions of nitrogen, phosphorus, and potassium prior to retail sale. Other physical and chemical characteristics of competing/complementary products are acceptable for the uses for which the products are intended. These products have a reputation and proven track record which enhances their desirability.

COMPOST USES AND MARKETS

Five primary market segments with significant potential uses for compost were identified. They are:

- agriculture;
- landscape industry;
- nursery industry;
- public agencies; and
- residents.

Uses of different types of compost (e.g., yard trimmings or MSW) in each market are affected by each market’s needs as to quality, composition, and appearance, as well as by applicable regulations.

Table ES-4

COMPETING/COMPLEMENTARY PRODUCTS IDENTIFIED

Soils

Topsoil
Pulverized topsoil
Screened topsoil
Fill dirt
River-bottom silt

Wood Products

Bark mulch
Wood chips

Other Products

Potting soils
Custom soil mixes
Livestock manure and manure compost
Peat
Livestock bedding and litter
Perlite
Vermiculite

Agriculture

The agriculture industry is the largest potential market for compost although it is the most difficult to penetrate. Studies have shown that the sustained application of compost to soil has many beneficial effects. Some of the problems 'that need to be overcome to develop the market are availability of compost, consistency in composition and nutrient content, ensuring low levels of potentially toxic substances, the effectiveness of bulk application, distribution methods, effect on yields, cost, and acceptance by farmers.

Landscape Industry

The landscape industry, which includes residential landscapers, uses large amounts of soil amendments. Soil with poor physical properties can be significantly improved by the correct use of compost. Areas of new planting could benefit from the use of compost to improve the quality of existing soil rather than replacing the soil with topsoil at a potentially higher cost. However, landscapers have expressed concern that compost from yard trimmings may contain harmful amounts of viable seeds, herbicides, and pesticides. Making results of laboratory tests demonstrating the safety of yard trimmings compost available to landscapers should alleviate these concerns. Other factors important to the utility of compost in the landscaping industry include availability, distribution channels, and cost .

Nursery Industry

The potential for using compost in the nursery industry is greatly dependent on the economy and the housing industry. Home sales have a direct effect on the demand for nursery products. Quality, availability, distribution channels, and cost 'are also important to the utility of compost in the nursery industry.

Public Agencies

Public agencies have the potential to use large quantities of both high-quality and low-quality composts. High-quality compost can be used in areas where humans and/or animals may come in contact with the compost. Lower-quality, relatively stable composts may be suitable for land reclamation, fill material, and landfill cover. Other uses by public agencies include:

landscaping and redevelopment;
weed abatement on public lands;
land upgrade; and
roadway maintenance and median strip landscaping.

Residential

The residential segment represents a substantial market for soil amendments. The amount of compost that the residential segment will use in the future is largely dependent on the ability to consistently produce a quality product, regulations, distribution channels and form, availability, public education, cost , as well as population growth, the economy, and the housing industry.

FACTORS PERTINENT TO DEVELOPING COMPOST MARKETS

Compost Specifications

Quality, which is very important for developing markets for compost, can be defined by a set of specifications. However, specifications have not been uniformly developed for composts and other soil amendments. Specifications for soil amendments could include a number of parameters from the following list, some of which overlap:

organic matter content;
water-holding capacity;
bulk density;
size distribution (i.e., particle size);
nutrient content;
level of contaminants;
concentration of potentially toxic compounds;
concentration of weed seeds;
seed germination and root elongation;
soluble salts;
ratio of available carbon/nitrogen;
pH ;
color; and
odor.

Compost Testing Requirements

Although procedures for testing the above parameters exist, a standard procedure for testing composts has not been established across the U.S. Some public and private producers of compost conduct their own tests and guarantee levels of nutrients and other constituents. Positive test results can enhance the marketability of compost products, although testing adds to costs.

Compost Distribution

The method and cost of transporting compost from the compost processing facility to the distribution center or user can play a critical role in the cost-effectiveness of the composting facility. Compost can be expensive to transport over long distances relative to its economic value. Bulk transportation, in some cases, may be feasible by rail (trips of several hundred miles) or ship (when there is access to navigable waterways). However, local distribution will usually be the most desirable, with bulk or bagged compost carried primarily by truck.

Compost Policies

Policies regarding compost use can be implemented on the Federal, State, or local level and can be in the form of guidelines or regulations. Most compost use policies have only recently been developed or are still in the developmental stages. Policies and regulations can affect:

- environment;
- public health and safety;
- program implementation; and
- distribution, cost, and use of the product.

Examples of environmental and public health and safety policies are those that regulate the siting and operation of composting facilities and those that affect compost quality. Yard trimmings compost is regulated less stringently than composts from mixed MSW or biosolids (also referred to as municipal sewage sludge) because the compost typically contains a much lower level of contaminants and poses less potential to harm the environment and public health. Efforts to regulate compost quality have focused on the process and the finished product. These efforts include controlling the feedstock to avoid contamination, maintenance of high temperature levels to ensure pathogen and weed seed destruction, and developing compost quality standards. Labeling standards can also be developed so that users are aware of the product content and quality.

Policies encouraging the implementation of composting programs have resulted in greater quantities of compost produced and marketed. Programs have been both voluntary and mandatory. Table ES-5 summarizes policies in the study regions which affect compost program implementation.

Policies that affect the distribution and use of the product are probably the least developed. Policies that give purchasing preference to compost could do much to encourage use of the product. Also, policies that give compost a lower-transportation rate, and policies regarding bid specifications for materials needed by governmental agencies, would have a beneficial effect on compost market development.

Table ES-5

MUNICIPAL SOLID WASTE MANAGEMENT POLICIES IN THE SIX STUDY REGIONS (July 1989)

	Central	Industrial	Midlands	Northeast	Pacific	South
Number of States	14	8	5	7	3	11
Number with MSWM I./plans currently in place	1	7	5	7	2	4
Number planning to have MSWM MSWM 1/ plans in place within two years	2	1	0	0	1	4
Number of MSWM 1/ plans providing mandatory guidelines	0	1	1	4	0	1
Number of MSWM 1/ plans providing voluntary guidelines	3	7	4	3	3	7
Number which gave composting higher priority than combustion	3	6	4	3	3	6
Number which ban landfilling of yard trimmings	0	3	4	1	0	2

____

(continued)

Table ES-5 (cont.)

List of States	AZ	DE	IL	CT	CA	AL
	co	IN	IA	ME	OR	AR
	ID	MD	MN	MA	WA	FL
	KS	MI	MO	NH		GA
	MT	NJ	WI	NY		KY
	NE	OH		RI		LA
	Nv	PA		VT		MS
	NM	WV				NC
	ND					SC
	OK					TN
	SD					VA
	TX					
	UT					
	WY					

1/ MSWM = municipal solid waste management.

BARRIERS TO DEVELOPING COMPOST MARKETS

Economic and noneconomic barriers to developing and/or expanding compost markets have been identified. At least some of these barriers may be faced in establishing a composting program.

Economic Barriers

Economic barriers that can hinder developing and/or expanding compost markets are:

- failure to identify potential markets;
- cost pressures from competing products;
- post-processing costs;
- transportation costs; and
- impacts of competing product capital investment.

Noneconomic Barriers

Noneconomic barriers that can adversely affect developing and/or expanding compost markets have also been identified. These noneconomic barriers are:

- compost quality assurance;
- user attitudes;
- location of markets with respect to compost operations;
- access to transportation routes;
- comparative availability of compost;
- product procurement policies;
- restrictions on compost use; and
- legal constraints.

Economic and noneconomic barriers must be avoided or overcome to enhance the marketability of compost products.

STRATEGIES TO MITIGATE/OVERCOME BARRIERS TO DEVELOPING COMPOST MARKETS

Overcoming Economic Barriers

Diversification of compost products can increase their overall market opportunities. Identifying the potential compost markets is important to determine their desired quantity and quality of compost. This allows post-processing and other production factors (e.g., quantities of different grades of compost) to be adjusted to meet the markets' needs.

Compost must be shown to be of equal or greater benefit and value to compete successfully with other products. Compost can be offered free or at a reduced price to attract users and markets though this may lower its perceived value. Compost can also be promoted as an ingredient or source of input material to manufacturers and suppliers of competing or complementary products.

Post-processing costs can be recovered if the post-processing sufficiently increases the value of the compost, and, in doing so, satisfies a market demand. Therefore, this potential barrier is avoidable by recognizing when and to what extent post-processing is necessary.

The barrier of transportation costs can be mitigated by one, or a combination of several, measures, including:

- modifying transportation rate structures to be more in favor of the compost product;
- obtaining lower backhaul rates where available or taking advantage of backhaul routes;
- increasing the value of compost (e.g., by screening and/or bagging) so that it is better able to economically bear the cost of transportation;
- locating the composting facility at, or close to, the primary users' location(s); and
- finding and developing markets in the immediate local area in which the compost is produced.

Overcoming the impacts of competing product capital investment can be difficult. One method is through the use of financial incentives, such as consumption tax credits, sales and property tax exemptions, grants, and low interest loans. Also, lower bulk-rate prices may be offered to potentially large users of compost.

Overcoming Noneconomic Barriers

Measures that would mitigate or overcome noneconomic barriers include:

- formulating an acceptable set of standards and specifications;
- providing product guarantees;
- enhancing the product's recognition factor;
- providing information on the benefits and uses of compost;
- working with university agricultural and cooperative extension services and soil and water conservation districts to develop and expand compost markets;
- providing the public with technical assistance;
- meeting with professional groups to influence product acceptance;
- establishing distribution centers at strategic locations;
- satisfying user demands for compost; and
- modifying or removing conflicting or restrictive legal and regulatory constraints.

Also, developing and maintaining favorable user attitudes (especially as concerns mixed MSW compost), and replacing biased procurement policies with unbiased or favorable ones would help to overcome these barriers. A telephone hotline for information on compost availability would also be beneficial.

Each of these strategies acts upon one or more of the identified noneconomic barriers. Quality assurance (by testing, if need be) and compost or labeling specifications appear to be two of the more favorable strategies that would be beneficial to aid in mitigating many noneconomic barriers. Likewise, they may also contribute to overcoming at least some of the economic barriers. However, different markets require different quality material. Consistency and uniformity of a lower grade product may meet the demand of some markets, while a higher quality, higher grade of compost is required by other markets. This stresses the importance of developing quality compost products that meet the needs of specific markets.

Chapter 1

INTRODUCTION

Municipal solid waste (MSW) generation in the United States is increasing. An estimated 196 million tons of MSW were generated in 1990 and generation is expected to increase to over 220 million tons per year by the year 2000 (l). At the same time, landfill disposal capacity is decreasing and new landfills are becoming more difficult to site. Approximately one-third of the MSW landfills in 1989 are expected to be closed by 1993 (2). Also, as overall landfill capacity decreases, disposal fees are rising (3). As a result, officials at all levels of government are looking to source reduction and recycling (including composting) to help alleviate their MSW disposal problems.

Composting yard trimmings (including leaves, grass clippings, and brush) and other organic materials from the MSW stream is one management technique with considerable promise for many areas of the country. However, as composting activity expands, greater attention is needed to develop and expand markets for finished compost in order to make composting a more effective MSW management tool and avoid possible oversupplies of compost. This is particularly important as markets for compost become more competitive with increased composting activity.

STUDY OBJECTIVE

The objective of this study is to provide information to help stimulate markets for compost, including yard trimmings compost and MSW compost. This involves identifying and evaluating existing and potential markets for compost and, also, the products that compete with, or complement, compost in those markets. In addition, the economic and noneconomic barriers to developing and/or expanding compost markets must be recognized and strategies developed to mitigate or overcome those barriers. Thus, the markets and compost products that will allow the greatest potential for increased uses of compost can be more effectively pursued.

The information contained in this report will be useful to producers, marketers, and users of compost, as well as to municipal, State, and Federal solid waste management officials. Persons considering development of new markets for compost (perhaps through increased production of compost or upgrading its product quality) or analyzing the feasibility of a new composting facility should also find this information helpful.

ROLE OF COMPOSTING IN MUNICIPAL SOLID WASTE MANAGEMENT

Reducing the volume of MSW that must be combusted or buried has become a priority for many communities around the country. The U.S. Environmental Protection Agency (EPA) has established a national goal of reducing the MSW disposed of by 25 percent through source reduction and recycling (including composting) (2). Composting is a process which can divert organic materials, such as yard trimmings and food scraps, from MSW disposal facilities and convert them into useful products. Therefore, composting can conserve landfill space, save on MSW disposal costs, and produce a valuable soil amendment product.

Composting is a biological process of stabilizing organic matter under controlled conditions into a product that is rich in humus and provides organic matter and nutrients, as well as carbon dioxide, water, and heat as by-products. The composting process achieves both volume and weight reduction. The composting process can range from low technology, where the material is piled or put into windrows and left to break down with infrequent turning, to high technology, which involves frequent turning with specialized machinery and/or more controlled aeration and moisture levels using a variety of specialized equipment.

Composting Yard Trimmings

Yard trimmings, which include grass clippings, leaves, brush, and tree prunings, are estimated to comprise 19 percent of the annual MSW discarded nationally. This amounts to about 31 million tons of yard trimmings discarded per year nationwide (1). However, according to numerous MSW characterization studies, individual locales have demonstrated a wide range in the amount of yard trimmings generated (as a percentage of their MSW).

Yard trimmings exhibit a great deal of seasonal and regional variations due to climatic and other influences, such as topography, population density, vegetation, and soil types. Grass clippings are generated in greatest volume from late spring to early fall. Leaves are generated in relatively shorter periods during the fall. However, areas of the country with a year-round growing season often generate large amounts of yard trimmings throughout the year. Seasonal peaks of yard trimmings can place hardships on traditional collection and disposal methods.

Landfilling and combustion (through incineration or waste-to-energy facilities) are not ideally suited to the management of yard trimmings. Landfilling of yard trimmings occupies rapidly dwindling disposal space and can be inefficient. Also, as yard trimmings decompose in a landfill they contribute to release of methane gas (a potential problem if uncollected for energy generation), and acidic leachate, as well as uneven settling (4). Yard trimmings are generally undesirable for combustion due to their high moisture content which may inhibit complete combustion and result in very little net usable energy for power or steam generation. Burning yard trimmings may also contribute greater nitrogen oxide and carbon dioxide emissions. The seasonal nature of yard trimmings generation poses problems for the design of combustors to ensure that they not be oversized or operate inefficiently (4). Composting can be an efficient method for dealing with yard trimmings since it may be more cost-effective than disposal, treats these materials as a resource, and produces a humus product which can provide organic matter and nutrients to the soil.

Landfill capacity pressures and the common practice of household separation of yard trimmings have helped to prompt hundreds of municipalities to implement yard trimmings composting programs. It has been estimated there were at least 986 yard trimmings composting facilities as of the end of 1989 operating in the United States, an increase of over 50 percent in just one year (5). The trend is encouraged by legislative measures, some of which ban disposal of yard trimmings in landfills. Ten States (and the District of Columbia) had passed legislation as of the end of 1989 prohibiting the disposal of some or all yard trimmings **in** landfills (see Table l-l). In addition, various States are addressing composting in their MSW management plans or anticipating legislative initiatives regarding composting (6).

Composting Other Municipal Organic Materials

Other organic materials, such as food scraps and non-recycled paper, also lend themselves to composting. For example, food scraps generated by residential, commercial (e.g., restaurants) , institutional (e.g., school cafeterias), and industrial (e.g., factory lunchrooms) sources are estimated to be about 8 percent of the nation’s MSW stream, or more than 13 million tons annually (l). Food scraps also vary by locale as to percentage of MSW, depending on such factors as economics, lifestyle, season, etc.

Furthermore, food scraps are generally not separated from the remainder of the MSW stream as yard trimmings tend to be. Therefore, they are not as readily available for composting. If not properly dealt with during the composting process, food scraps may also attract vermin and insects, and create odor problems since they tend to decompose rapidly.

MSW composting, though currently not very common in the U.S., is a method of managing the compostable organic portion of MSW. Besides yard trimmings, other components of MSW, such as food scraps and non-recycled paper, are also decomposable. Other components of the MSW stream do not readily decompose, are noncompostable, or are undesirable in the compost, and are usually removed either before or after the composting process. If not, presence of household hazardous waste, for example, could

Table 1-1

STATE BANS ON LANDFILLING YARD TRIMMINGS (as of 1989)

State	Date Effective	Yard Trimmings Banned
Connecticut 1/	1/1/91	Leaves only
Florida	1/1/92 (from lined landfills only)	Vegetative matter including stumps and branches
Illinois	7/1/90	All landscaping trimmings, grass, leaves, and trimmings
Iowa	1/1/91	Not yet specified
Minnesota	1/1/90 (7-county metro area) 1/1/92 (rest of State)	Yard trimmings including clippings, boughs, etc.
New Jersey	8/89	Leaves only
North Carolina	1/1/93	All yard trimmings
Ohio	1/1/93	Leaves, grass, brush, and other wood bits
Pennsylvania	9/26/90	Leaves only
Wisconsin	1/1/93	Leaves, grass, and small woody bits under 6 inches

1/ Leaves are included in the State's list of recyclable items and therefore must be recycled.

Source: Glenn, J. "Regulating Yard Waste Composting." BioCYcle, 30(12):38-41. December 1989.

contribute toxic constituents to the finished compost product, lowering its marketability.

MSW composting can generally process up to 30-60 percent of the MSW stream with the remainder being recovered for recycling, composting a segregated component, combustion, or landfilling (7). The method is typically capital intensive, requiring construction of a physical plant and the dedicated use of heavy equipment.

Composting source separated MSW refers to the processing of only organic materials suitable for composting which have been segregated at the point of generation. Mixed MSW composting involves the processing of the entire MSW stream without separation at the point of generation, but rather separation at the composting facility with varying degrees of effectiveness. The type of collection selected should consider and carefully balance costs and equipment needs for collection as well as processing, quality, marketability, and value of the recovered products (i.e., compost and recyclable), total diversion rates from disposal facilities, the public perception toward composting and recycling, etc. (8).

Livestock manure from farms and animal feedlots (including poultry operations) can be composted with yard trimmings or other organic materials. Due to its relatively high nutrient levels, livestock manure can be a desirable additive to the composting mixture, or composted separately with a bulking agent. Livestock manure is typically generated at farms and animal feedlots and not included in the MSW stream. However, livestock manure generated by feedlots and other concentrations of livestock can be a source of surface or ground water pollution. Therefore, livestock manure collected for composting from feedlots may lead to water quality benefits.

Biosolids (also referred to as municipal sewage sludge), which can also be composted, is not covered in this report because it has been extensively covered in other reports.

NEED FOR DEVELOPING COMPOST MARKETS

Markets for compost must be identified and developed since, if no demand for the compost exists, the cost for storing the compost increases and disposal costs may be incurred. Therefore, it is essential that a market be found for the anticipated supply of compost products. Whether the compost is sold or given away, it is important to identify and secure end users to have a successful composting program.

Also important in developing a market development strategy for compost is determining its present and future supply. However, this study has not attempted to estimate existing and future compost supplies for the nation due to the following:

- lack of accurate (or reliable) estimates for the composition of the yard trimmings (i.e. , the percent contribution of leaves, grass clippings, brush, etc.);
- which yard trimmings and remaining municipal organics will be composted (or mulched) ;
- existing and projected composting levels; and
- the quality of the compost.

It is estimated that approximately 12 percent of the nation's yard trimmings (i.e., 4.2 million tons) were composted in 1988 (l). To estimate the amount of compost produced from this feedstock, there is roughly an average 50-percent weight reduction by composting yard trimmings (4)(9). However, it is expected that in at least some cases, mulch was produced rather than compost.

Diversification of compost products can increase overall market opportunities. Compost has been successfully marketed in bulk or bag. Therefore, there is no single “best” method to market a compost product.

Primary markets for yard trimmings compost have thus far been municipalities and local residents. Markets beyond these users have been more difficult to develop and maintain. However, yard trimmings compost has also been marketed to soil amendment dealers, landscapers, nurseries, farmers, greenhouses, land developers, and others. Markets for MSW compost are still being established because the product is relatively new in the United States. Market development obstacles include competitive pricing of other related products, a lack of uniform user specifications, inconsistent or lack of regulations, maintenance of consistent quality, contaminants in the finished product, and transportation distance and costs.

SCOPE OF REPORT

This study is based primarily on a review of the appropriate related literature and information obtained from informal discussions with compost marketing experts and compost users, as well as others potentially involved in using compost (e.g., horticulture, agriculture, land reclamation, and other applications) .

This nationwide compost market study was conducted on a regional basis. As shown in Figure 1-1, the following six regions were defined: Central, Industrial, Midlands, Northeast, Pacific, and South. As demonstrated by Figure 1-1, the definition was not based on size in terms of land area. Rather, criteria such as MSW management activities and characteristics, geographic region, and

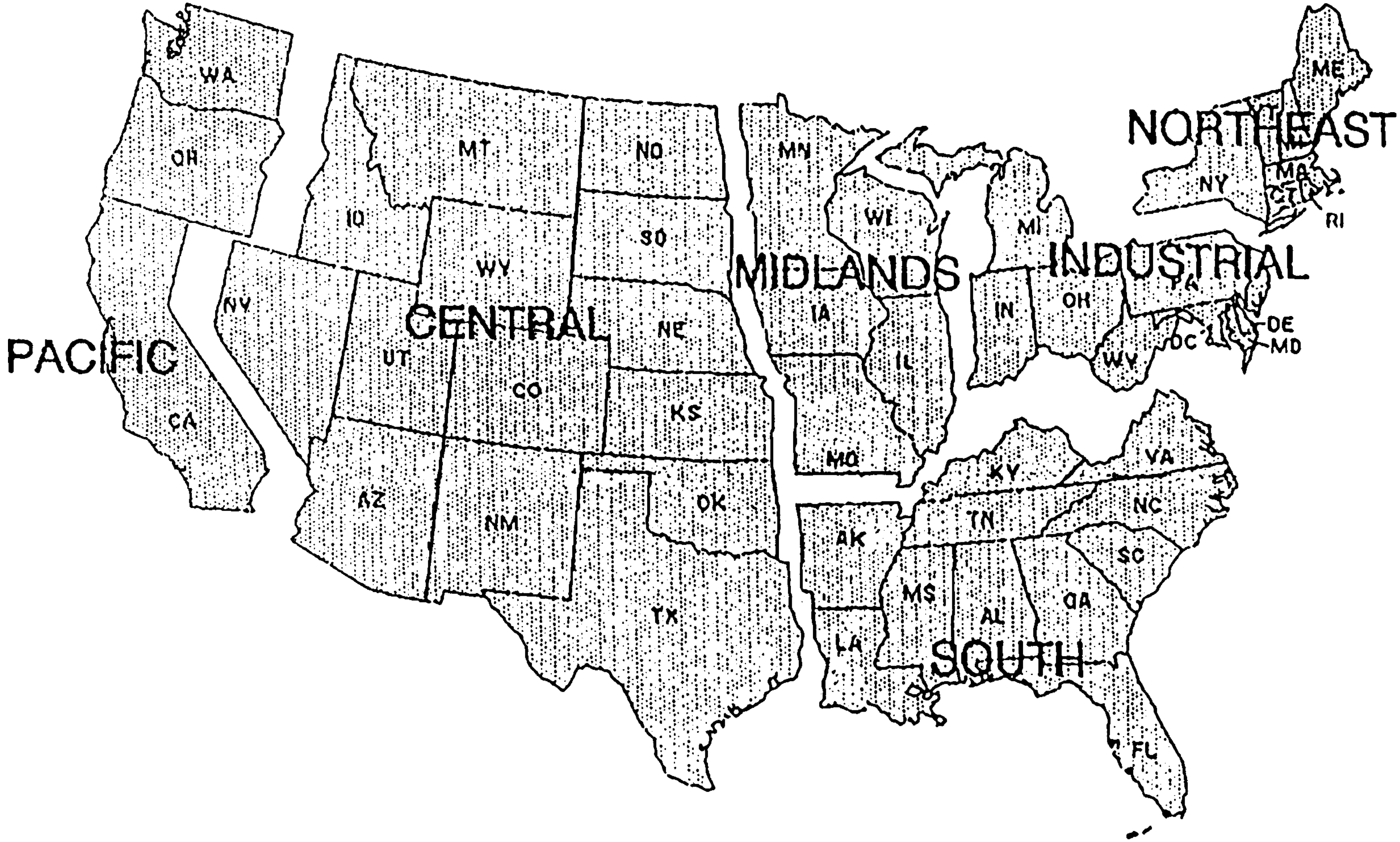

Figure 1-1. Regions of the United States as defined for the study.

population density were given consideration in determining the regional definitions.

Characteristics and benefits of compost and competing/complementary products are discussed in Chapter 2. Chapter 3 identifies potential uses and markets for compost. In Chapter 4, factors pertinent to developing and/or expanding compost markets are presented, including specifications and testing requirements. Economic and noneconomic barriers to increased development and/or expansion of compost markets are identified in Chapter 5. Chapter 6 presents strategies to mitigate or overcome these barriers. An overview of existing composting programs and their compost markets is contained in Appendix A. This study should provide useful information and direction which can lead to expanded markets for compost and increased composting activity.

Chapter 1

REFERENCES

1. U.S. Environmental Protection Agency. Characterization of Municipal Solid Waste in the United States: 1992 Update. Executive Summary. EPA/530-R-92-O19. July 1992.

2. United States Environmental Protection Agency. The Solid Waste Dilemma: An Agenda for Action. Municipal Solid Waste Task Force. Office of Solid Waste. September 1988.

3. Pettit, C.L. “Tip Fees Up More Than 30% in Annual NSWMA Survey.” Waste Age, 20(3) :101-106. March 1989.

4. Taylor, A.C. and R.M. Kashmanian. Yard Waste Composting: A Study of Eight Programs. United States Environmental Protection Agency. Office of Policy, Planning and Evaluation; Office of Solid Waste and Emergency Response. EPA/530-SW-89-038.

5. Glenn, J. “The State of Garbage in America: Part 1.” BioCycle. 31(3) :48-53. March 1990.

6. Glenn, J. “Regulating Yard Waste Composting.” BioCycle, 30(12) :38-41. December 1989.

7. United States Environmental Protection Agency. The Solid Waste Dilemma: An Agenda for Action, Background Document. Municipal Solid Waste Task Force. Office of Solid Waste. September 1988.

8. M.M. Dillon and Cal Recovery Systems, Inc. Composting: A Literature Study. Prepared for Ontario Ministry of the Environment. 1989.

9. Smith, W.H. “Organic Waste Management in Florida.” BioCycle, 31(4):52-55. April 1990.

Chapter 2

CHARACTERISTICS AND BENEFITS OF COMPOST AND COMPETING/COMPLEMENTARY PRODUCTS

This chapter examines the characteristics and benefits of yard trimmings compost and MSW compost, as well as the characteristics and benefits of competing/complementary products. Appendix A includes information for developing markets for primarily yard trimmings compost. Together, this information is important to producers and users of compost since their product must be a suitable replacement for other products or create a new demand, to gain acceptance and successfully compete.

CHARACTERISTICS AND BENEFITS OF COMPOST

Compost is a valuable soil amendment. For example, improvements in physical properties of soil that can result from using compost include:

- improved soil porosity;
- improved water retention;
- improved soil infiltration;
- improved resistance to erosion;
- enhanced storage and slow release of nutrients;
- decreased soil crusting;
- improved soil tilth; and
- plant disease suppression (l)-(7).

The greatest improvements in the physical properties of soil occur at the extremes of soil texture; that is, with light or sandy soils at one extreme and heavy or clay soils at the other. The addition of compost to sandy or light soils, due to the organic matter in the compost, increases their ability to retain water and lessens the effects of drought and heavy rain. Added organic matter loosens clay soils, increases their permeability to air and water, and improves their water retention (3) (4).

Due mainly to its organic matter and humus content, compost also helps to reduce erosion and improve plant growth. This can substantially reduce nutrient transport in surface runoff to water systems, since sediment is a major transport vehicle for phosphorus and nitrogen (8) . Thus , the addition of compost to soil not only reduces erosion and recycles nutrients, but also provides important water quality and economic benefits.

Research and experience have also shown that some composts will inhibit soil-borne pathogens, reducing the incidence of plant diseases in nurseries, gardens, and specialized commercial cultivation of plants. Bark composts and certain other composts display the ability to suppress certain soil-borne plant diseases, although the mechanism by which this works is not fully understood at present. Not all composts exhibit this disease suppression trait. Nevertheless, the use of these composts by the horticultural industry has all but ended certain plant diseases that used to sweep through the nursery industry routinely. A related benefit is the reduced use of fungicides that had been used to fight plant diseases (l)(2)(5)-(7).

It should be recognized that characteristics and, therefore, benefits of compost depend on several factors. These factors include the materials used as feedstocks, the effectiveness of source- and facility-separation techniques, the level of contamination by foreign material (e.g., noncompostables) , chemical residues, or heavy metals that may be present, the chosen composting technology, and the level of expertise and quality control measures applied during the composting process.

The soil benefits of adding mulch derived from yard trimmings should also be considered. These benefits include:

- increased moisture retention in the soil;
- reduced evaporation;
- reduced soil spattering from rainfall;
- reduced soil compaction;
- reduced soil erosion;
- suppressed weed growth;
- reduced use of pesticides; and
- moderated soil temperature.

Feedstocks for MSW composting will likely be different than those for yard trimmings composting. Essentially, the entire organic portion of the MSW stream is a potential feedstock to mixed MSW composting, depending the effectiveness of facility separation. This includes non-recycled paper, and food scraps, as well as yard trimmings. Also, it becomes more likely that other materials, such as pieces of metal, glass, and plastics, may be mixed in with the feedstocks during mixed MSW composting. Not only is quality control more difficult, but end uses may also be more limited. However, a number of separation systems are offered to overcome these problems. These processes vary by degree of materials separation before, during, and after the composting process and the resulting compost product quality varies accordingly.

The uses of mixed MSW compost may be more limited than yard trimmings compost due to potentially higher heavy metal content, the presence of glass, metal, and plastic objects, and possible negative public perceptions. However, MSW and mixed MSW composting have the capability of composting a larger portion of the municipal stream than yard trimmings composting alone. Frequent testing of mixed MSW compost is needed to determine its heavy metal content, other potential toxics, presence of pathogens and, thereby, identify acceptable uses of the end product.

Physical and chemical characteristics, including carbon-to-nitrogen ratio, nutrient value, pH, heavy metals, presence of potentially toxic substances, and soluble salts, are described below.

Physical/Chemical Characteristics. Mature compost is a relatively stable humus product. Uncured, or unstable, compost is still volatile and can compete with plants for nitrogen in the soil. This can be avoided by using mature, stabilized compost, so that this reaction does not occur after application.

Stable, mature compost would be expected to exhibit characteristics as discussed below.

Carbon/Nitrogen Ratio. Mature, stabilized compost should have an available carbon to nitrogen (C/N) ratio of about 15-20:1 (weight/weight ratio). Compost having an excessively high C/N ratio can lead to nitrogen deprivation for plants as discussed above (9) . Achieving a compost with a C/N ratio near 15-20:1 can be achieved with the right combination of feedstocks and time. Table 2-1 shows the C/N ratios of various possible yard trimmings feedstocks.

Carbon/nitrogen ratios above 30:1 for feedstocks mean a slower composting process initially because microbial growth is limited by the amount of nitrogen available. As carbon is metabolized and released as carbon dioxide, the C/N ratio improves and the composting process speeds up. The ideal C/N ratio for composting is approximately 25-30:1. This is seldom achieved initially with leaves unless they can be mixed with a nitrogen source (e.g., with grass clippings) to produce the ideal C/N ratio (9)(10).

Nutrients. Yard trimmings compost is low in macronutrients (nitrogen, phosphorus, and potassium -- NPK) and therefore is not a one-for-one substitute for inorganic fertilizer. Generally, the percentage of each of the elements N, P, and K is less than one or two percent dry weight (10).

One of the most comprehensive testing programs for yard trimmings compost is performed by the Metropolitan Service District (Metro) in Portland, Oregon. An analysis on yard trimmings compost produced in Portland found total NPK to vary between 1.39 and 1.78 percent dry weight (11). A similar analysis on mixed MSW compost found the nitrogen, phosphorus, and potassium contents were 1.08, 0.35, and 0.76 percent dry weight, respectively (11).

Although its NPK is generally low, compost, because of its organic nutrient content, has the advantage of releasing nutrients slowly to the plants so that the nutrients may be used over a

Table 2-1

C/N RATIO OF VARIOUS MUNICIPAL ORGANIC MATERIALS

Material	**C/N Ratio**
Grass clippings	12-20:1 1/ 2/ 2/ 4/
Food scraps	15:1 4/
Fruit scraps	35:1 2/ 3/ 4/
Leaves	40-80:1 2/ 3/ 4/
Bark	100-130:1 4/
Paper	150-200:1 3/ 4/
Sawdust	200-510:1 1/ 2/ 3/ 4/
Wood	700-725:1 3/ 4/
Wood chips	800:1 2/

Sources:

1/ Golueke, C.G. Biological Reclamation of Solid Wastes. Rodale Press. Emmaus, Pennslyvania. 1977.

2/ May, J.H. and T.W. Simpson. The Virginia Yardwaste Management Manual. Virginia Polytechnic Institute and State University. Prepared for the Virginia Department of Waste Management. 1990.

3/ Poincelot, R.P. The Biochemistry and Methodology of Composting. The Connecticut Agricultural Experiment Station, New Haven. Bulletin 754. September 1975.

4/ Richard, T.L.; N.M. Dickson; and S.J. Rowland. Yard Waste Management: A Planning Guide for New York State. Co-Sponsored by New York State Energy Research and Development Authority, Cornell University Cooperative Extension, and New York State Department of Environmental Conservation. June 1990.

period of years. Annual applications can build up reserves of nutrients, possibly providing a greater fertilizing effect than the NPK measurement would indicate (10)(12). However, precautions should be taken to prevent the nutrients or unwanted substances from being accumulated to undesirable or unacceptable levels.

Compost is often a good source of micronutrients (trace elements such as iron, manganese copper, zinc, boron, molybdenum, chlorine, and cobalt) which plants also need, but in smaller amounts compared to macronutrients. Except for iron, and in some cases manganese, trace elements are found sparingly in most soils, and their availability to plants is often very low.

Portland's quarterly testing program of yard trimmings compost also indicates calcium in the range of 0.25-0.47 percent and magnesium in the range of 0.06-0.09 percent. Traces of copper, manganese, iron, and boron are also indicated (13) .

pH. The acidity or alkalinity of a substance is represented by a number on a logarithmic scale from O to 14, which is called pH (see Figure 2-1) . Numbers below 7 are increasingly acidic, 7 is neutral, and numbers above 7 are increasingly alkaline.

The composting process is relatively insensitive to the pH of its feedstocks (9). Finished compost generally ends up with a pH around neutral, usually between 6 and 8, according to tests performed on finished, stable compost (9) (11)-(14). Therefore, properly cured compost is suitable for most plants, although certain acid-loving plants may need a lower pH (which can be attained by the addition of a supplement, such as sulfur) .

<u>Heavy Metals</u>. Several areas of the United States have tested yard trimmings compost for heavy metal content. In two years of sampling for lead, average high concentrations ranged between 92 and 128 milligrams per kilogram in Minnesota. The highest recorded sample was 380 milligrams per kilogram in the heart of St. Paul. This was attributed to vehicle exhaust along roadways from leaded gasoline. These concentrations were within limits considered safe by the State (15) . In analysis conducted by Cornell University, heavy metal concentrations found in leaf compost were significantly lower than State standards for Class I compost (see Table 4-8) (16). Research performed at a leaf composting site in Newton, Massachusetts found lead levels that ranged between 130 and 190 milligrams per kilogram (17) . Tests conducted in Portland, Oregon found relatively low concentrations of heavy metals (11) (13). These results are presented in Chapter 4, Table 4-6, along with the test results for mixed MSW compost from Minnesota and mixed MSW and biosolids compost from Delaware. These data suggest that heavy metal concentrations are normally not a concern in yard trimmings compost due to their low levels of concentration. However, they are a greater concern in mixed MSW

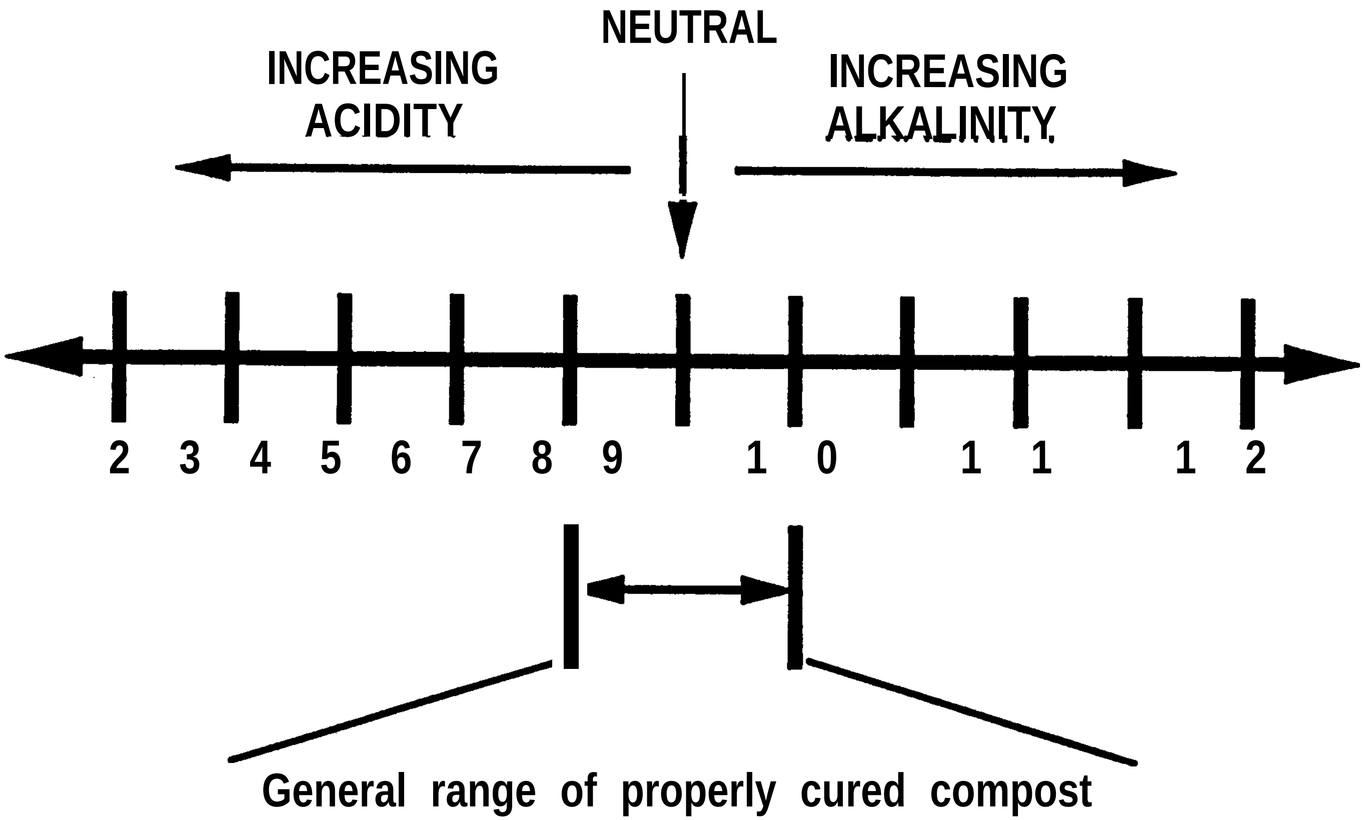

Figure 2-1. pH scale showing the general range of finished, stabilized compost

compost due to higher concentrations in the feedstock of some heavy metals such as lead, mercury, and cadmium.

Herbicides, Pesticides, and Other Potential Toxics. Some of the most extensive testing of yard trimmings compost for potential toxic contamination has probably occurred in Portland, Oregon. Nineteen compounds are tested for, including commonly used pesticides and herbicides. Four compounds were found at extremely low levels and were determined to be of no concern as they would not be toxic to seed germination or plant growth (11) (13).

A study by Cornell University on leaf compost reported pesticide residue analysis results that indicated presence of captan, chlordane, lindane, and 2,4-D. Of these, all except chlordane were found in concentrations well below the United States Department of Agriculture (USDA) food tolerance level. The study states the USDA food tolerance level provides a conservative indicator of compost safety and, since the chlordane-related compounds are low relative to background levels in suburban soils and are tightly bound to the compost itself, these residues should not constrain the use of compost (16). Also, the presence of toxic organics is diminished over time due to their breakdown during the composting process.

Toxic substances, such as household hazardous wastes, should be removed from MSW prior to composting (e.g., through source separation, household hazardous waste collection, and up-front separation at the composting facility) to minimize contamination of the compost product.

Pathogens. A properly maintained composting process should eliminate the concern for pathogens. Temperatures in excess of 55 degrees Celsius are needed over at least three days to ensure adequate pathogen destruction using in-vessel or aerated static pile composting methods. Using the windrow composting method, temperatures must attain 55 degrees Celsius or greater over at least 15 days during the composting period. There must be a minimum of five turnings of the windrow during the high temperature period (18). These procedures should assure complete pathogen destruction throughout the windrow.

Portland, Oregon has tested for human and animal pathogens in yard trimmings compost. Pathogens were either not detected or found in low concentrations. The only pathogens found were those normally found in soils. The pathogens were at acceptable levels, and concluded to be due to reintroduction into the compost after composting (11)(13).

Soluble Salts. Total soluble salts (also expressed as electrical conductivity level) is a measure of water soluble salts (or salinity) present in soil or compost to which plant roots will be exposed. An exceedingly high salinity (above 8-10 millimhos per centimeter) may adversely affect the growth of plants and crops, especially that of seedlings. The electrical conductivity level of compost intended for application to plants or crops should not exceed two millimhos per centimeter. Compost with a greater conductivity level may be diluted with a low-salinity medium to lower the overall conductivity to a safe level. Tests in Portland on yard trimmings compost have found total soluble salt concentrations to be at safe levels (0.17-1.9 millimhos per centimeter) (13). Tests performed by Cornell University on yard trimmings compost have also found levels far below what would cause harm to plants (16). A test performed on mixed MSW compost also found an acceptable conductivity level (1.95 millimhos per centimeter) (19)-(21).

CHARACTERISTICS AND BENEFITS *OF* COMPETING/COMPLEMENTARY PRODUCTS

Potential markets for compost produced from the above organic materials are primarily those which competing/complementary products already satisfy. Therefore, successful market development and distribution of compost depends upon the ability to consistently provide a similar or superior product at a reasonable price, when compared to existing products.

An informal survey of vendors was conducted for this study to determine the types, demand, quality, and cost of yard trimming and MSW compost, and their competing (and complementary) products. Information that could not be obtained by this method was collected from available literature. A listing of the competing/complementary products identified is included in Table 2-2. Table 2-3 provides information on the bases by which compost competes with, or complements, these products. These products have a long history of use in agriculture, construction, horticulture, landscaping, and residential gardening. Some of the uses for the materials include the following: soil amendment, soil aeration, moisture retention, soil stabilization, erosion control and repair, growing medium, decorative cover, and land reclamation.

The products are sold in bulk or in bag either by weight or volume. Bulk materials generally are sold in quantities greater than 2 cubic yards. Bagged products typically range from one to four cubic feet in size. Sources of these materials range from the immediate vicinity of the market to national distributors, as well as importation from Canada. As such, the price of each of these products varies depending upon location, availability, and season.

The uses and characteristics of the competing/complementary products mentioned above are discussed in the following subsections. With the exception of the nutrient content levels, manufacturers rarely report or display the characteristics (i.e., particle size, pH, elemental analysis) of their product, especially when sold in bulk form. Thus, characteristics presented in this

Table 2-2

COMPETING/COMPLEMENTARY PRODUCTS IDENTIFIED

soils

-Topsoil
-Pulverized topsoil
-Screened topsoil
-Fill dirt
-River-bottomsilt

Wood Products

-Bark mulch
-Wood chips

Other Products

-Potting soils
-Custom soil mixes
-Livestock manure and manure compost
-Peat
-Livestock bedding and litter
-Perlite
-Vermiculite

Table 2-3

COMPETING/COMPLEMENTARY PRODUCTS WITH COMPOST

Material	Degree of Competition 1/ Compete	Degree of Competition 1/ Complement	Basis of Competition	Use as Complement
Top Soil	xx	x	Organic matter Porosity Moisture retention	Mixed with topsoil for specific applications
Fill Dirt	--	x	--	Compost placed on top of fill dirt
Bark Mulch and Wood Chips	xx	--	Moisture retention Weed control Erosion prevention	--
Potting Soils	xx	x	Moisture retention Porosity Organic matter	Mixed for special needs
Manures	x	xx	Porosity Organic matter	May be mixed with manure
Peat	xx	x	Moisture retention Porosity	Mixed with peat and other amendments in potting soil blend
Livestock Bedding and Litter	x	x	Moisture retention	Mixed with other bedding materials

(continued)

Table 2-3 (cont.)

Perlite	--	X	--	Mixed with perlite and other amendments as potting soil blend
Vermiculite	--	X	--	Mixed with vermiculite and other amendments as potting soil **blend**

1/ X indicates one particular use.
XX indicates multiple uses.

report are based on average compositions. The characteristics, of course, vary depending upon the region and source of materials.

Soils

The types and characteristics of soils sold nationwide depend upon the predominant local soil type and its expected use. In general, three types of soils have been identified: topsoil, fill dirt, and river silt. Topsoil may be pulverized and/or screened depending upon the range of particle size, uniformity, and degree of purity from contamination required by the buyer.

Information regarding nutrient content, particle size, and soil types was either unknown or not provided by compost vendors contacted during the study. Several vendors indicated that this information may not be necessary since large users of soils visually inspect the product before sale.

Soils are sold in all areas. Soils are typically required by the construction industry and landscapers to increase the elevation of an" area, to minimize erosion, as a growth medium, or as fill material. Screened topsoil is more readily available in the Industrial and Northeast regions of the country. Individual vendors can experience fluctuations in availability depending upon their source of supply. Some vendors located within metropolitan areas obtain soils for resale from excavation companies. When regional excavation activity is low, vendors may not be able to meet the demand for soils.

Based upon qualitative information supplied by vendors, demand for soils depends upon two critical factors: time of year, and economic development activity. Demand for soils is greatest during spring and autumn, which tend to be the most active construction and landscaping seasons. Seasonal demand becomes more pronounced as one moves north and east across the United States. Economic development activity, as measured by construction and commercial improvement activity, was mentioned by all vendors as another primary barometer of soil sales. Vendors in Georgia and Louisiana stated that the demand for soil was low.

The prices of soils, by region, are presented in Table 2-4. Prices vary depending upon the distance from the site where the soils are extracted, the amount of physical processing desired by the purchaser, and the quantity of soils purchased. Prices indicated in Table 2-4 generally reflect local delivery of bulk quantities (6 to 20 cubic yards) of soil.

It is unlikely that compost will replace soils in every possible application. Compost can be used to prepare specialized soil mixtures and thus displace only a fraction of the soil typically used. Compost may be able to replace up to 20 percent (by weight) of the soil.

Table 2-4
AVERAGE PRICES FOR TOPSOIL AND FILL DIRT (1989)

Region	Product	Price 1/	Delivery 2/
Northeast			
Boston, MA	Screened topsoil	$17.00	D
Hartford, CT	Screened topsoil	$15.00	P
	Topsoil	$ 9.50	P
Industrial			
Pittsburgh, PA	Topsoil	$10.00	P
	Screened topsoil	$12.50	P
	Shredded & screened topsoil	$15.00	P
	Screened topsoil	$12.00	P
South			
Atlanta, GA	Fill dirt	$10.00	P
	Topsoil	$12.00	P
Birmingham, AL	Topsoil	$17.50	P
		$ 3.99 3/	
Little Rock, AR	Fill dirt	$ 2.50	P
	Topsoil	$ 3.00	P
New Orleans, U	Topsoil	$17.00	D
		$ 2.00 3/	P
Richmond, VA	Topsoil	$12.00	D
Midlands			
Chicago, IL	Topsoil	$ 4.00	P
	Screened topsoil	$18.00	D
Cleveland, OH	Topsoil	$19.00	D
St. Paul, MN	Topsoil	$ 9.50	D
	Pulverized topsoil	$ 9.50	D
	Topsoil	$ 2.99 3/	P
Central			
Boise, ID	Topsoil	$ 5.00	D
Kansas City, MO	Topsoil	$ 8.90	D
	Pulverized topsoil	$12.00	D
Phoenix, AZ	Fill dirt	$ 9.95 4/	P
	Screened topsoil	$13.50 4/	P
	River silt	$13.95 4/	P
Pacific			
San Diego, CA	Screened topsoil	$11.50	P
	Amended topsoil	$14.00	P
Santa Cruz, CA	Topsoil blend w/compost	$27.95	P
	Fill dirt	$11.00	P

1/ All prices are per cubic yard unless otherwise indicated.
2/ D= local delivery (generally less than 10 miles; P = picked up at site.
3/ Price is for 40-pound bag.
4/ Price is for one ton of material.

Bark Mulch and Wood Chips

Competing wood products include bark mulch, sawdust, and wood chips. Wood products are used extensively by landscapers and homeowners to conserve moisture and for decorative purposes. In addition, wood chips and bark mulch are used in stabilizing steep slopes and for rejuvenating soils severely disturbed by mining or construction activities. Wood chips and bark mulch reduce erosion from raindrop splash and protect new seedlings. Lastly, using wood chips as a garden mulch is reported to suppress plant diseases, reducing the damage from nematodes (l).

The average composition of hardwood and softwood sawdust is provided in Table 2-5. As shown in the table, the nutrient value of wood is relatively low. These materials should not be tilled into the soil since significant amounts of nitrogen would be needed to supplement that used by microorganisms during decomposition and this may tie up otherwise available nitrogen. Most barks tend to be acidic with a pH between 4 and 5, although the pH increases during the aging process. The cation exchange capacity (CEC) of bark also increases during decomposition. The CEC is the total amount of exchangeable cations that a soil (or soil amendment) can sorb and is measured in milliequivalents per 100 grams of soil. Among the exchangeable cations are some of the required plant nutrients. In addition, the soil can also sorb nonessential cations and in essence retain heavy metals. Sawdust, which is generally recommended to be composted and aged prior to its use in potting soils, has adequate CEC for sorption of cations. The average bulk density and particle size of various growth media are presented in Table 2-6.

Sources of bark mulch include cedar, cypress, and pine. Bark mulch can be marketed in various sizes to accommodate the preference of the consumer. Depending on the type and quantity, retail prices for bagged bark mulch can range from $1.70 to $5.00 per cubic foot. Bulk prices for bark mulch and wood chips can range from $12 to $30 per cubic yard (see Table 2-7).

Based upon comments received during this study, the use of wood chips by office park developers and residents is now in vogue and has become an important retail market in regions where soil sales have suffered due to an economic downturn. Wood **chips** are used as a protective mulch cover for the existing soil.

A percentage of the compost made from yard trimmings will compete directly with mulches and wood chips. The exact amounts will depend upon the type and degree of processing. Coarse size reduction will result in the production of a material suitable for either use as mulch and wood chips or a composting feedstock.

Table 2-5

AVERAGE NUTRIENT COMPOSITION OF WOOD

Woody Plant Group	Nitrogen (Percent wet weight)	Phosphorus (Percent wet weight)	Potassium (Percent wet weight)
Hardwoods	0.20	0.03	0.15
Softwoods	0.10	0.03	0.10

Source: Follet, R.H.; L.S. Murphy; and R.L. Donahue. Fertilizers and Soil Amendments. Prentice-Hall, Inc. England Cliffs, New Jersey. 1981.

Table 2-6

AVERAGE BULK DENSITY AND PARTICLE SIZE OF VARIOUS GROWTH MEDIA

Material	**Bulk Density (Dry g/ml)**	**Particle Size**
Pine Bark	0.12	2 to 5 mm
	0.21	0.5 to 1 mm
	0.30	<0.5 mm
	0.25 to 0.27	Mixed
Peat Moss		
Fine	0.03	<10 mm; 90% <6 mm
Medium	0.10	<38 mm; 80% <6 mm
Coarse	0.14	19 to 38 mm
Perlite	0.21	2 to 5 mm
Vermiculite	0.11	1 to 2 mm

Source: Handrick, K. and N. Black. Growing Media for Ornamental Plants and Turf. New South Wales University Press. Kensington, NSW, Australia.

Table 2-7

AVERAGE PRICES FOR BARK MULCH AND WOOD CHIPS (1989)

Region	Product	Price 1 /	Delivery 2 /
Northeast			
Boston, MA	Bark mulch	$20.00	D
	Wood chips	$30.00	D
Industrial			
Pittsburgh, PA	Bark mulch	$14.00	P
South			
Atlanta, GA	Bark mulch	$12.00	P
Birmingham, AL	Bark mulch	$20.00	P
		$ 3.99 3 /	P
New Orleans, LA	Bark mulch	$20.00	D
Richmond, VA	Bark mulch	$16.00	D
Midlands			
St. Paul, MN	Bark mulch	$ 4.99 4 /	P
	Cedar chips	$ 4.95 4 /	P
Central			
Dallas, TX	Bark mulch	$25.00	P
Pacific			
Portland, OR	Bark mulch	$13.00	D
	Wood chips	$12.00	D

1 / All prices given are per cubic yard unless otherwise indicated.
2 / D= local delivery (generally less than 10 miles); P = picked up at site.
3 / Price stated is for one cubic foot.
4 / Price stated is for three cubic feet.

Potting Soils

Because of difficulties experienced in obtaining natural soils that meet detailed specifications, the horticulture industry began seeking alternative mixtures for potting soils 40 years ago (22). The first feedstocks developed were based on mixtures of peat and sand. Today, a variety of materials are used, including soils, peat, clay, compost, perlite, sand, sawdust, vermiculite, and vermicompost (which is made by worms) . Compost may not be able to compete directly with potting soils. However, compost can become an ingredient in some potting soils, e.g., used as an ingredient comparable to peat in potting soils.

A variety of potting soils are commercially available using different mixtures of these materials. As such, the price for potting soils depends upon the composition of the mixture, grade of materials used, location, and manufacturer. The current retail and bulk prices for a variety of potting soils and soil mixtures are provided in Table 2-8.

Livestock Manure and Manure Compost

Manures produced by confined domestic livestock (including poultry) were estimated at 990 million tons (dry weight) per year in the mid- to late-1970s (23). It was estimated that approximate ely 47 million tons (dry weight) of the manure were available for cropland application: Quantities and types of livestock manures used for application on croplands in the U.S. were estimated to be as follows: dairy cattle, 17 million tons; beef cattle, 13 million tons; swine, 11 million tons; broilers, 4 million tons; and laying hens, 3 million tons (24).

There may be some competition between compost and manures. The competition depends upon the compost feedstock and the type of manure. Increased use of manures for agricultural purposes is presently hampered because large feedlots generally may not be located in the vicinity of croplands. Compared to chemical fertilizers, any cost advantage for livestock manure is eliminated if long distance transport is required. Furthermore, most large feedlots are located in arid and semi-arid regions of the U.S., where insufficient croplands or pasturelands are available for the appropriate application of manure (e.g., excess loadings of nitrogen can affect ground or surface water) . If the level of nitrogen added to the soil is excessive, surface and/or ground water may be negatively affected if runoff and/or leaching problems ensue.

Because of its nutrient value and organic matter content, livestock manures enhance plant growth and crop production. Manures may be applied wet or dry. Direct application of wet or dry manures should be done carefully in order to prevent negative

Table 2-8

AVERAGE PRICES FOR VARIOUS SOIL AMENDMENTS (1989)

Region	Product	Price	Unit	Delivery 1/
Northeast				
Boston, MA	Peat	$12.00	6 cu ft bale	P
Hartford, CT	Potting soil 2/	$20.00	1 cu yd	P
Industrial				
Newark, NJ	Soil mix 3/	$18.00	1 cu yd	P
Pittsburgh, PA	Mushroom manure compost	$20.00	1 cu yd	P
South				
Atlanta, GA	Manure compost	$10.00	1 cu yd	P
Birmingham, AL	Potting soil	$30.00	1 cu yd	P
		$ 3.99	40 lb bag	P
Midlands				
Chicago, IL	Manure compost	$ 1.99	40 lb bag	P
	Peat moss	$ 9.95	4 cu yd bale	P
	Peat humus	$ 1.69	40 lb bag	P
	Potting soil	$ 2.59	40 lb bag	P
St. Paul, MN	Manure compost 4/	$ 1.99	45 lb bag	P
	Manure compost 5/	$ 3.99	45 lb bag	P
	Peat moss	$ 5.49	1 cu ft	P
	Potting soil	$ 2.99	40 lb bag	P
Central				
Phoenix, AZ	Soil mix 6/	$14.95	1 cu yd	P
	Soil mix 7/	$15.95	1 cu yd	P

(continued)

Table 2-8 (cont.)

Pacific				
San Diego, CA	Manure compost	$12.75	1 CU yd	P
	Screened manure compost	$14.00	1 CU yd	P
Santa Cruz, CA	Proprietary mix	$27.50	1 CU yd	D
	Mushroom compost	$12.95	1 CU yd	D
	Potting soil	$ 2.00	1-1/2 Cu ft	D
	Planting mix	$ 2.00	1-1/2 Cu ft	D

1/ D = local delivery (generally less than 10 miles); P = picked up at site.
2/ Mixture includes soil, peat, and leaf compost.
3/ Mixture includes soil and leaf compost.
4/ Steer manure.
5/ Sheep manure.
6/ Mixture includes soil, leaf mulch, and sand.
7/ Mixture includes soil, river silt, and manure.

impacts on water quality. Studies comparing equivalent nitrogen, phosphorus, and potassium applications from livestock manures and chemical fertilizers have demonstrated more favorable results with manure in terms of yields (23), as well as reduced nitrate leaching (25)(26). It is explained that the addition of manure to the soil increases its concentration of organic matter, increases its infiltration rate, and decreases its bulk density.

The composition of livestock manures varies according to its origin. In addition, the diet, type, and age of the animal, and storage conditions will affect the composition of the manures. The characteristics of manures from six types of livestock animals are presented in Table 2-9. As shown in the table, the density of the manures is approximately 63 pounds per cubic foot. Total solids range from 8.6 percent for swine to 25 percent for sheep. Values for volatile solids, biochemical oxygen demand (BOD5), and chemical oxygen demand (COD) are also presented. Total kjeldahl nitrogen (a method to determine the concentration of nitrogen) varies from 2.9 percent for horse manure to 7.5 percent for swine manure. Phosphorus ranges from 0.49 to 2.5 percent, as a percent of total solids; potassium ranges from 1.8 to 4.9 percent. Approximately 70 percent of the nitrogen in uncomposted manure is water soluble. This is important for-water quality reasons since the nitrogen may be more leachable to ground water and could negatively affect the water quality.

The livestock manure sold at retail stores, or used by landscapers and horticulturists, is usually composted, relatively dry, and free of odors. Prices reported for composted manure range from $1.99 to $3.69 for a 45-pound bag. These composted manures have nitrogen, phosphorus, and potassium contents of 0.5 percent (wet weight) each. Average prices for livestock manure composts are included in Table 2-8.

Compost, particularly that produced from yard trimmings, can compete with composted or uncomposted livestock manures. The displacement can be on a one-to-one ratio or in some instances only a portion of the manures in order to take advantage of the beneficial properties of both materials.

Peat

Peat is used extensively by horticulturists, greenhouse operators, and to a lesser degree by landscapers and homeowners. In 1988, 1.468 million tons of peat were sold and used in the U.S. (including .59 million tons imported). The average sales price was $18.14 per ton in bulk and $24.68 per ton in package or bale (27)

One of the most important features of peat is its capacity to absorb and retain water, and at the same time maintain adequate quantities of oxygen. It is valued as a substrate for the rooting

Table 2-9

AVERAGE CHARACTERISTICS OF LIVESTOCK MANURES

Characteristics	Dairy	Beef	Swine	Sheep	Poultry	Horse
Density (lb/cu ft)	62.7	63.0	63.0	NA	65.5	NA
Total solids (% of raw manure)	10.8-12.7	11.6-12.8	8.6-9.2	25.0	25.2	20.5
Volatile solids (% of total solids)	82.5	85.0	75.0-80.0	85.0	70.0	80.0
BOD 5 (% of total solids)	16.6	23.0	30.0-33.0	9.0	27.0	NA
COD (% of total solids)	68.1	95.0	90.0-95.0	118.0	90.0	NA
Kjeldahl nitrogen (total)	3.4-3.9	3.5-4.9	7.5	4.5	5.4-6.8	2.9
Phosphorus as P (% of total solids)	6.7-3.9	1.6	2.5	0.66	1.5-2.1	0.49
Potassium as K (% of total solids)	2.6	3.6	4.9	3.2	2.1-2.3	1.8

NA = no data available.

Source: Agricultural Engineers Yearbook. 1981.

of slippings because it is free of weeds, diseases, and pests, and it is readily penetrated by plant roots (22).

Peat is found in swampy areas in cool climatic zones. It is produced by incomplete decomposition of plant matter by microorganisms under wet, anaerobic conditions (22).

Peat is divided into the following main categories (23):

Peat moss--mainly sphagnum and hypnum mosses. The fibers aereadily identifiable because they have not been noticeably decomposed. This is the most acid, the most expensive, and the most desirable of the peat mosses.

Reed-sedge peat--a mixture of residues from reeds, sedge grasses, and cattails.

Humus peat--produced from the advanced decomposition of hypnum moss and reed-sedge peat.

Muck soil--highly decomposed peat of any source, usually mixed with mineral soil, often sold as "topsoil."

The physical and chemical properties of peat depend on the species, degree of decomposition, and proportion of mineral matter. As shown in Table 2-6, the average bulk density of peat is 0.1 gram per milliliter. Peat is divided into three main grades: fine (with particle size less than 38 millimeters and 90 percent less than 6 millimeters), medium (with particle size less than 38 millimeters and 80 percent less than 6 millimeters), and coarse (with particle size greater than 38 millimeters). As stated earlier, one of the most important physical properties of peat is its ability to absorb water. Commercially available peat can absorb 15 to 20 times its weight in water.

Table 2-10 presents the chemical characteristics of four different types of peat. As shown, peat has a low pH (3.8 to 4.6) and an ash content no greater than 8 percent. Concentrations of nitrogen, phosphorus, potassium, and calcium are also presented in the table. An ultimate analysis of peat indicates the following characteristics: carbon, 56.8 percent; hydrogen, 5.6 percent; sulfur, 0.3 percent; and oxygen, 34.6 percent (28) .

Peat is usually distributed in bales or bags. The sizes of the bags range from 1 to 4 cubic feet (compressed). Commercially available peat is often pH balanced (5.0 to 6.0) and is guaranteed to be 98 percent root-free. Sphagnum peat moss is reported to have a retail cost between $2 and $5 per cubic foot, depending on the grade (see Table 2-8).

Table 2-10

CHEMICAL CHARACTERISTICS *OF* DIFFERENT PEAT TYPES
(Percentages on oven dry basis)

Peat Type	Ash	N	P	K	Ca	pH
Sphagnum	*1-2*	0.8- 1.2	0.01- 0.04	trace- 0.03	0.07- 0.21	3.8- 4.2
Sphagnum[N] Eriophorum (cotton-grass)	1-3	1.0- 1.6	0.01- 0.05	0.01- 0.03	0.14- 0.25	3.9- 4.6
Trichophorum (deer-grass)	1-4	1.5- 2.0	0.01- 0.05	0.01- 0.05	0.14- 0.21	4.0- 4.5
Sedge-grass	2-8	1.5- 2.5	0.04- 0.07	0.02- 0.07	0.14- 0.36	4.2- 4.6

Source: Robinson, D.W. and J.G. Lamb. Peat in Horticulture. Academic Press. New York. 1975.

A high quality compost made from yard trimmings, for example, or some of its components, can be very competitive with peat, based on moisture retention and porosity.

Livestock Bedding and Litter

The increasing demand for animal products and by-products, along with the marginal nature of certain types of agricultural operations, and diminishing availability of land for siting livestock operations, have resulted in a growing dependence upon high density animal housing facilities in which the animals are closely confined. This dependence is especially widespread in poultry and dairy cattle operations. The confinement and high density trends have engendered a heavy demand for bedding and litter materials -- a demand that is increasingly difficult to meet. The industries and activities that generated the residues and other materials conventionally used as bedding have experienced a sharp decline. Dwindling Supply, competition for these materials, and transportation requirements combine to render the monetary cost of these materials prohibitively high in many cases. Accordingly, there is a search for new materials worthy of serious consideration for use as livestock bedding (e.g., recovered newspapers and phone books).

A suitable bedding material is one that is easy to handle and has a high moisture holding capacity. It must either be devoid of pathogens and toxic inorganic and organic substances or have them at or below acceptable concentrations. It must be reasonably available and priced. Additionally, the moisture content of the material should not be so high as to cause it to adhere to the animal or so low as to make the material a source of dust. The moisture holding capacities of several potential bedding materials are listed in Table 2-11. Other materials that can supplement the list in the table are various composts, whether derived from livestock manure, yard trimmings (see Table 4-2 for its water-holding capacity), or almost any other organic material (obvious exceptions are hazardous wastes).

At present, two uses of compost in animal husbandry are as poultry litter and as dairy cattle bedding. Although use as bedding in commercial horse stables (renting and/or boarding horses) could be a third use, findings made in an unpublished survey reveal that the strong concern on the part of the stable operators over the possibility of the exposure of the horses to disease transmission and/or toxic contaminants is a major obstacle to the realization of that potential (29).

<u>Dairy Cattle Bedding</u>. In addition to having been a feature of long standing in dairy cattle husbandry, bedding has become a necessity in free stall dairy housing facilities to keep the animals clean and comfortable. Bedding absorbs urine and renders manure easier to handle. As stated above, the absorption function

Table 2-11

MOISTURE ABSORBING CAPACITIES (MACs) OF SEVERAL LIVESTOCK BEDDING AND LITTER MATERIALS

Material	Saturated Moisture Content (% dry basis)	MAC units/ unit total solids	Typical As-Stored Moisture Content (% dry basis)	MAC
Peat Moss	1,195.0	11.9	13.6	10.4
Oat Straw, Baled, and Chopped	537.4	5.4	16.8	4.5
Mill Sawdust, Stored Uncovered	532.1	5.3	309.8	0.5
Hay, Baled	410.9	4.1	8.7	3.7
Recycled Manure, Wood Shavings Bedding	394.6	3.9	12.4	3.4
Light Coarse Sawdust, Stored Under Cover	338.4	3.4	38.5	1.8
Wood Shavings, Kiln-Dried	299.6	3.0	4.7	2.8
Peanut Hulls, Unground	291.3	2.9	10.4	2.5
Heavy Fine Sawdust, Stored Under Cover	282.2	2.8	38.5	1.8

(continued)

Table 2-11 (cont.)

Source: Sobel, A.T.; D.C. Ludington; and Kim-Van Yow. "Altering Dairy Manure Characteristics for Solid Handling by the Addition of Bedding." Paper No. NA77-410 presented at 1977 Annual Meeting, North Atlantic Region, American Society of Agricultural Engineers. University of New Brunswick, Canada. July 31 - August 3, 1977.

makes water absorption capacity a key factor in evaluating candidate bedding materials. Table 2-12 lists the absorption capacities of a more extensive collection of potential bedding materials than listed in Table 2-11.

The reasons given above regarding the search for sources of bedding material are particularly applicable to the dairy cattle industry. Hence, it is not surprising that compost has become a leading candidate. Use of compost as bedding material was seriously explored as early as 1971 in a study on the role of composting in a comprehensive study of management and utilization of manure from high-density cow housing facilities (30) (31). An interesting feature of this study was the gradual replacement of the original bedding material with composted manure, such that eventually composted manure became the sole bedding material. The forced air (static pile) composting method was used. It was determined essential that the manure bedding be removed from the stalls as soon as its moisture content reached 70 percent. In addition, 70 percent is the highest moisture level at which the forced aeration system could be successfully used.

In recent years, hydraulic manure management (i.e., periodic flushing and transport) has become commonplace in dairy housing sanitation. Solids separated from the resulting manure slurries can be composted and the liquids either are ponded or subjected to treatment. Separation generally is done mechanically, i.e., by means of screens (32). composting usually is by one of three methods, namely, forced aeration (“static pile”) , turned windrow, or “natural aeration" (33) (34). (“Natural aeration” involves stacking the material in windrows and allowing air to diffuse without assistance into the piles.)

The possibility of transmission of disease-causing organisms between animals through the use of composted manure as bedding was investigated by Clemson University in 1978 to determine survival rates of pathogenic organisms and the temperature increases in the composting piles (34). The piles were sampled every four days. Results indicated a sharp decrease in numbers of streptococci and salmonella. The drop in pseudomonades and coliforms was less steep, and the number of staphylococci remained fairly constant at an infectious level (i.e., 10,000 staph/gram) after an initial drop. In all cases, temperature played a significant part.

A major question is the effect of compost bedding on the incidence of udder infections, especially mastitis. The authors state that it is generally believed that bedding materials are second to the milking machine in terms of exerting a major influence on the type of bacteria infections that are found in the udder. Past data justify the conclusion that the type of bedding may affect the bacterial populations on the teat skin. The authors found no significant difference in bacteria counts between teats and milk of animals bedded on composted dairy manure and clean

Table 2-12

WATER ABSORPTION CAPACITY OF LIVESTOCK BEDDING MATERIALS

Bedding Material	Pounds of Water Per Pound of Bedding	Bedding Material	Pounds of Water Per Pound of Bedding
Barley straw	2.10	Sand	.25
Cocoa shells	2.70	Sugar cane bagasse	2.20
Corn stover (shredded)	2.50	Vermiculite	3.50
Corncobs (crushed or ground)	2.10	Wheat straw (long)	2.20
Cottonseed hulls	2.50	(chopped)	2.95
Flax straw	2.60	Wood	
Hay (mature, chopped)	3.00	Dry fine bark	2.50
Leaves (broadleaf)	2.00	Tanning bark	4.00
(pine needles)	1.00	Pine chips	3.00
Oat hulls	2.00	Sawdust	2.50
Oat straw (long)	2.80	Shavings	2.00
(chopped)	3.75	Needles	1.00
Peanut hulls	2.50	Hardwood chips	1.50
Peat moss	10.00	Shavings	1.50
Rye straw	2.10	Sawdust	1.50

Source: Ensminger, M.E. Dairy Cattle Science. Interstate Printers' Publishers, Danville, Illinois. 1990.

rubber mats. Thus, there appeared to be no direct relation between bedding and udder infection. The critical factor is good management. If cows are well cared for, if the milking process is performed properly with effective sanitation practices and teats dipping, and if free stalls are cleaned periodically, mastitis infection would be minimal. In general, the type of bedding appears to have no direct relationship to incidence of udder infections, if good management practices are observed **(34)** .

<u>Poultry Litter</u>. The **use of compost as a poultry litter can** be traced back to the 1950s (35). At that time, the "deep litter" (or "thick litter") approach in poultry husbandry was strongly recommended by its users and was fairly widely used in the U.S. and the Netherlands.

In the deep litter method, hens and chicks are left on a 12-to 20-inch thick layer of organic matter such as straw, corn cobs, wood shavings, horse manure, peat bedding, or Compost. The birds spend their entire life on this bedding. Provided that an intensive bacterial flora generating heat develops in the layer, and the layer is properly maintained, the bedding may be used for 3 to 4 years without renewal. If necessary, the bedding layer can be turned (aerated) or fresh organic matter may be mixed with it. Among the several advantages attributed to the use of this approach are a healthier flock and somewhat greater gain in body weight. Apparently, the birds develop an immunity against coccidiosis.

In the years that followed, the use of litter (not necessarily the deep litter approach) has continued to be an important feature in the production of broilers and turkeys. Sawdust and wood shavings became the material most commonly used because it is clean and, until recently, it was the cheapest in most situations. However, the dwindling availability of bedding and litter materials and search for other materials discussed above have brought about a renewed interest in the use of compost for poultry litter.

In three experiments involving a total of 33,920 broilers, the utility of composted municipal garbage (CMG) as broiler litter was evaluated (36) . The compost was obtained from two sources, namely aerobically digested CMG and windrow processed CMG. They were each compared to a wood shavings control. Broilers reared on CMG compost were respectively 31, 12, and 44 grams heavier than those reared on the wood shavings control. Feed efficiency was also improved. However, the type of litter treatments had little or no effect upon other production or carcass characteristics. Judging from the few published reports, select trace elements and pesticide levels in CMG litter and tissue as compared with wood base litter were generally within previously reported levels. Exceptions were high mercury, lead, chromium, and nickel in CMG litter. Additional research would be necessary for quantifying the significance of the high levels.

If the views of one study are taken as being typical, the outlook for compost as litter material for turkey houses had become much less hopeful by 1990 (37). Their objection is that birds produced on litter were somewhat dirtier than those grown on shavings. This dirtiness would add more production costs. Moreover, recycled litter could not be expected to satisfy completely the bedding requirement for a given operation, because of a 15-20 percent loss in volume during the composting process. This study concludes that more work must be done before compost can be recommended for use as bedding material.

An idea of the dimensions of the bedding use for compost in various poultry management schemes may be gained from the data in Table 2-13.

Others

Among the other soil amendments available in the market are vermiculite, perlite, and vermicompost. These materials are mainly used as additives for potting mixes, although they are relatively expensive. A brief description of each of these materials is provided below.

Perlite. Perlite is a porous siliceous material produced by the rapid heating of natural volcanic glass to 1,200 degrees Celsius. It is completely inert, without any buffering capacity, and no nutrients. Perlite is used primarily in potting mixes, because it has a similar water-holding capacity to peat. As shown in Table 2-6, the bulk density of perlite is relatively low. Compost can be used with perlite and other amendments for special potting soil blends. Perlite retails for approximately $7.20 for a 4-cubic foot bag. In 1988, 49.3 thousand tons of perlite were sold and used as horticultural aggregates (includes fertilizer carriers), at an average price of $30.65 per ton of all perlite sold (27).

Vermiculite. Vermiculite is a flaky mineral with a plate-like structure that occurs naturally. The raw mineral is crushed, graded, and then rapidly heated to 1,000 degrees Celsius. Rapid heating results in particle expansion (exfoliation) to several times its original size. The density of the exfoliated vermiculite is similar to peat (see Table 2-6). Compared to perlite, vermiculite has a greater capacity to hold water, but has a lower air-filled porosity (i.e., the space between the particles) (38). This is due to its plate-like structure. Vermiculite provides some magnesium and potassium to plants. Compost can be used with vermiculite and other amendments for special potting soil blends. It is reported by those interviewed that vermiculite costs between $5.75 and $6.75 for a 4-cubic foot bag, depending on the grade. In 1988, 71.4 thousand tons of exfoliated vermiculite were sold and used in agricultural applications (i.e., for horticulture, soil

Table 2-13

BEDDING USE PER POULTRY MANAGEMENT SCHEME

System Type		**System Description**	**Pounds of Shavings Used Per Bird Produced**	
Broiler - System 1		- 5.5 Flocks per Year - Annual Cleanout		0.6
Broiler - System 2		- 6.0 Flocks per Year - 1/3 Cleanout Annually - Complete Cleanout Every 2 Years		0.26
Turkey - System 1	Hen	- 5.2 Flocks per Year - Brooder House Cleaned After Every Flock - Growout House Cleaned Annually	Brooder House Growout House	2.33 1.33 3.66
	Tom	- 4 Flocks per Year - Brooder House Cleaned After Every Flock - Growout House Cleaned Annually	Brooder House Growout House	3.5 2.5 6.0
Turkey - System 2	Hen	- 5 Flocks Annually - Brooder House Cleaned After Every Flock - Growout House Cleaned Annually	Brooder House Growout House	5.33 2.67 8.00
	Tom	- 4 Flocks Annually - Brooder House Cleaned After Every Flock - Growout House Cleaned Annually	Brooder House Growout House	8.00 5.00 13.00

Source: Safley, L.M., Jr. and T.A. Carter. "Use of Composted Litter as Bedding Materials for Broilers and Turkeys." Chapter 6 in <u>Composting Poultry Litter - Economics and Marketing Potential of a Renewable Resource</u>. North Carolina Agricultural Research Service, North Carolina State University, Raleigh, North Carolina. 1990.

conditioning, and as a fertilizer carrier) at an average price of $221 per ton of all exfoliated vermiculite sold (27).

Vermicompost. Vermicompost is produced from the castings of earthworms that feed on organic materials. Historically, only limited quantities of vermicompost have been available. Increased quantities of the product are expected for the future. Analysis of vermicompost produced from swine manure contained the following (on a dry weight basis): 4 percent nitrogen, 3.9 percent phosphorus, 0.9 percent potassium, 6.3 percent calcium, 2.0 percent magnesium, and 2.3 percent iron (38).

Chapter 2

REFERENCES

1. Hoitink, H.A.J.; W. Chen; M.I. Trilas-Gay; and Y.R. Chung. "compost for Control of Plant Diseases," in Compost Production, QualitY, and Use. M. de Bertoldi, M.P. Ferranti, P. Hermite, and F. Zucconi, eds. Elsevier Applied Science. pp. 414-419. 1986.

2. Hoitink, H.A.J. and G.A. Kuter. "Role of Composts in Suppression of Soilborne Plant Pathogens of Ornamental Plants." BioCYcle. 25(4):40-42. May/June 1984.

3. Hornick, S. "Organic Wastes for Revegetating Marginal Lands." BioCYcle, 23(4):42-43. July/August 1982.

4. Illinois Department of Energy and Natural Resources. Landscape Waste Compost: Distribution and Marketing Strategies for Centralized Municipal Composting Operations. Office of Solid Waste and Renewable Resources. March 1989.

5. Logsdon, G. "Compost for Pathogens." BioCYcle, 29(9):28. October 1988.

6. Logsdon, G. "New Sense of Quality Comes to Compost." BioCycle, 30(12) :48-51. December 1989.

7. Logsdon, G. "Plant protection Through Compost." BioCYcle, 31(1):52-54. January 1990.

8. North Carolina State University. "Best Management Practices for Agricultural Nonpoint Source Control, Volume I, Animal Waste." Biological and Agricultural Engineering Department. Raleigh, North Carolina. August 1982.

9. Willson, G.B. "Combining Raw Materials for composting.tl BioCYcle, 30(8):82-85. August 1989.

10. Michigan Department of Natural Resources. Yard Waste Composting: Guidebook for Michigan Communities. Resource Recovery Section. 1989.

11. Golueke, C.G; L.F. Diaz; and S. Gurkewitz. "Technical Analysis of Multi-Compost Products." BioCYcle, 30(6):55-57. June 1989.

12. Logsdon, G. "A Business-Like Approach to Leaf composting." BioCYcle, 30(3):22-24. March 1989.

13. Portland Metropolitan Service District. A User's Guide to Yard Debris Compost. Portland, Oregon. June 1989.

14. U.S. Environmental Protection Agency, U.S. Food and Drug Administration, and U.S. Department of Agriculture. "Land Application of Municipal Sewage Sludge for the Production of Fruits and Vegetables." U.S. Government Printing Office. Washington, D.C. 1981.

15. Schumacher, N. Compost/Co-compost Research Project Final Resort. Minneapolis-St. Paul Metropolitan Council. Minneapolis, Minnesota. 1987.

16. Richard, T. and M. Chadsey. "Croton Point Compost Site, Environmental Monitoring Program." Department of Agriculture and Biological Engineering, Cornell University. Prepared for Westchester County Solid Waste Division, Department of public Works. white Plains, New York. November 1989.

17. Fulford, B. and J. Quinney. Leaf Composting Projects in the Commonwealth of Massachusetts: Final Report. New Alchemy Institute. Falmouth, Massachusetts. 1987.

18. 40 Code of Federal Regulations. Chapter 1 - Part 257, Appendix II. July 1, 1988 edition.

19. Woods End Research Laboratory. Compost Standards: Towards Uniform Guidelines for Identification, Labeling and Testing. Working document presented to the American Composting Council. Washington, D.C. Undated.

20. Zucconi, F. and M. de Bertoldi. "specifications for Solid Waste Compost." BioCycle, 28(5):56-61. May/June 1987.

21. Fitzpatrick, G.E. "Solid Waste Composts as Growing Media." BioCycle, 30(9):62,64. September 1989.

22. Robinson, D.W. and G. Lamb. Peat in Horticulture. Academic Press. New York. 1975.

23. Follet, R.H.; L.S. Murphy; and R.L. Donahue. Fertilizers and Soil Amendments. Prentice-Hall, Inc. England Cliffs, New Jersey. 1981.

24. Frere, M.H. "Nutrient Aspects of Pollution from Cropland." Control of Water Pollution from Cropland: Volume II: An Overview. USDA Agricultural Research Service and U.S. Environmental Protection Agency. 1975.

25. Maynard, A.A. "Agricultural composts as amendments reduce nitrate leaching from soil." Frontiers of Plant Science, pp. 2-4. Fall 1989.

26. Brinton, W.F., Jr. "Nitrogen Response of Maize to Fresh and Composted Manure." Biological Agriculture and Horticulture, 3:55-64. 1985.

27. U.S Department of the Interior. Minerals Yearbook, Volume I: Metals and Minerals 1988. Bureau of Mines. 1990.

28. Punwani, D.V. "Peat as an Energy Alternative: An Overview,tl in symposium papers. Peat as an Alternative. December 1-3, 1980.

29. Cal Recovery, Inc. Private communication with various stable owners. 1982.

30. Senn, C.L. A comprehensive study of management and utilization of waste from high-density cow-housing facilities, Report to the Public Health Service. December 1971.

31. Senn, C.L. "Role of Composting in Waste Utilization." Compost Science, 15 (4): 24-29. September 1974.

32. Safley, L.H., Jr. & W.C. Fairbanks. "Separation and Utilization of Manure Solids." Dairy Housing II. Proceedings of the Second National Dairy Housing Conference. Published by American Society of Agricultural Engineers. March 1983. pp. 77-91.

33. Emerton, B.L.; C.R. Mote; H.H. Dowlen; J.S. Allison; and W.L. Sanders. "Comparison of Forced and Naturally Aerated Composting of Dairy Manure Solids". American Soc. Agricultural Engineers, 4 (2): 159,160. June 1988.

34. Bishop, J.R.; J.J. Janzen; and A.B. Bodine. "Composted solids from manure can be used in free stalls." Hoard's Dairyman, 125 (19): 1320-1321. Oct. 10, 1980.

35. Teensma, B. "Refuse Compost in Poultry Husbandry." Information Bulletin No.4, International Research Group on Refuse Disposal (IRGRD), March 1958.

36. Malone, G.W.; G.W. Chaloupka; and R.J. Eckroade."Composted Municipal Garbage for Broiler Litter." Poultry Science, 62 (3): 414-419. March 1983.

37. Safley, L.M., Jr. and T.A. Carter. "Use of Composted Litter as Bedding Materials for Broilers and Turkeys." Chapter 6 in Composting Poultry Litter - Economics and Marketing Potential of a Renewable Resource. North Carolina Agricultural Research Service, North Carolina State University, Raleigh, North Carolina. 1990.

38. Handrick, K. and N. Black. Growing Media for Ornamental Plants and Turf. New South Wales University Press. Kensington, NSW, Australia.

Chapter 3

COMPOST USES AND MARKETS

Successful market development of compost includes three main requirements: 1) producing a consistent quality and quantity of compost; 2) identification of a use or uses for the product; 3) identification of potential users (i.e., markets); and 4) acquainting prospective users with the compost and its uses. This chapter discusses the first two of these requirements, namely uses and markets for the compost products.

COMPOST USES

The utility of compost as a soil amendment has long been recognized. The greatest benefit of compost is its organic matter content. Following its incorporation into the soil, compost can improve the soil's texture, water retention, and aeration capacity. Compost also contains nutrients that can be helpful in plant production. The effects of compost use on the biological, chemical, and physical properties of soil, as well as on crop yields, are summarized below (1)-(10):

Compost enhances the biological properties of soil by:

- enhancing the development of fauna and microflora;
- rendering plants less vulnerable to attack by parasites; and
- promoting faster root development of plants.

Compost enhances the chemical properties of soil by:

- increasing nutrient content;
- turning mineral substances in soil into forms available to plants;
- regulating mineral input, particularly nitrogenous compounds;
- serving as buffer in making minerals available to plants; and
- providing a source of micronutrients.

Compost enhances the physical properties of soil by:

- improving soil texture;
- increasing water retention capacity;
- improving soil infiltration;
- improving resistance to wind and water erosion;
- improving aeration capacity;
- improving structural stability; and
- stabilizing soil temperatures.

Compost enhances crop yields by:

producing higher yields; and
inhibiting weed growth.

Although serving as a soil amendment is a principal use for compost, it can also be used in other applications including: 1) as a mulch to lessen evaporation and inhibit weed growth; 2) as a top dressing to improve the appearance of soil and discourage weed growth; 3) in hydromulching for use in erosion control and reforestation projects; 4) as bedding for dairy cattle and poultry litter; and 5) as a landfill cover.

Composts from different types of organic materials (e.g., yard trimmings, other municipal organics, and livestock manures) have different characteristics and, therefore, the uses for these products can differ. Typically, segregated yard trimmings have a more consistent composition than mixed MSW. Consequently, compost from yard trimmings generally has a more consistent quality than that from mixed MSW.

COMPOST MARKETS

Consistent product quality is generally considered to be the most important of the factors affecting the marketability of compost. Regardless of the type of composting operation, the quality of the product is a function of the biological, chemical, and physical characteristics of the product. Biologically; the product should be sufficiently mature; have a high concentration of organic matter; be free from pathogenic organisms; and should contain no active weed and plant seeds. Examples of desirable chemical characteristics are: available nutrients (NPK); minimal levels of heavy metals, PCBs, PCP, and pesticides and herbicides; and low salinity. Examples of pleasing physical characteristics are uniform particle size; absence of visually identifiable unwanted substances (e.g., glass shards, bits of plastic, pieces of metal) ; a moisture content less than 50 percent; a dark color; and a pleasant earthy odor.

In the absence of a complete nationwide survey, no attempt was made to quantify the full market potential for compost since this would depend on: type and amount of materials composted; type, number, and size of compost users; existing and new compost markets; compost quality; etc. Information on current levels of uses for some of the competing/complementary products is provided in Chapter 2. These figures are not available for all of these products since they may be produced and marketed locally.

Because of the beneficial characteristics of compost, the product can be used for many different applications-. 'These include: agriculture, grounds maintenance (e.g., golf courses, cemeteries, and athletic fields), highway construction and maintenance, hydromulching, industrial and commercial property landscaping, bare roots nurseries (i.e., only deal with a dormant stock and sold without growing medium), forest seedling nurseries and reforestation, sod farming, land reclamation, landfill cover, parks and recreational areas, and residential landscaping and gardening.

These applications can be broadly grouped into the following five primary market segments:

- agriculture;
- landscape industry;
- nursery industry;
- public agencies; and
- residential.

Various local and national organizations and groups represent these users, e.g., agricultural extension services, farm bureaus, soil and water conservation districts, landscape architect and contractor institutes, bark and soil supply associations, public works officials, and garden clubs. These types of organizations represent key target groups to involve to stimulate compost use by their members.

Uses of different types of compost in each market segment are constrained by that market's particular requirements for quality, composition, and appearance, as well as by applicable regulations.

Agriculture

The agriculture industry is the largest potential market for compost. Agriculture, however, remains the most difficult to penetrate. In general, given their experience and widespread use of chemical fertilizers, farmers would need to be convinced through field demonstrations and tests of the benefits of using compost (e.g., affects on costs, crop yields, soil structure, soil fertility, soil erosion) as well as the quantities of compost to apply, and the timing and method of application. However, in some parts of the country there are agricultural communities whose farming traditions differ and where large amounts of organic matter are incorporated into the soil. Also, there is an increasing trend to organic methods of farming which should increase the demand for organic-based soil amendments, such as compost, for use in agriculture. In addition, there is an increasing awareness that soil fertility is dependent upon maintaining a sufficient amount of organic matter in the soil. Compost is an excellent source of organic matter for maintaining soil fertility and reducing erosion (10)(11).

Studies have shown that the sustained application of compost has beneficial effects that include favorable soil pH, higher crop yields, increased organic matter, increased water retention, increased cation exchange capacity (i.e., ability of the soil to sorb nutrients, as well as heavy metals and other substances) , enhanced supply of plant nutrients, and improved tilth. Primary and secondary plant nutrient levels were increased significantly due to the long-term application of mixed MSW compost to field plots in Johnson City, Tennessee (3). Some of the problems that need to be overcome to develop the agriculture market for compost are its availability, consistency in composition and nutrient content, ensuring low levels of potentially toxic substances, effectiveness of bulk application, effectiveness of distribution methods, information on its contribution to crop yields and soil fertility, cost, and acceptance by farmers.

Landscape Industry

The landscape industry, including landscape service companies, uses large amounts of soil amendments: bark or barkdust, particularly in the Pacific Northwest, is frequently used as a top dressing; topsoil is used for new planting; and compost is used as a soil amendment. Soil with poor physical properties can be significantly improved by the correct use of compost. Research conducted by the USDA and by Rutgers University has shown that the use of compost combined with chemical fertilizers produces better turfgrass than when using the fertilizers alone (10).

Compost is not expected to completely displace bark as a top dressing because of the decorative appearance of bark. Areas of new planting could benefit from the use of compost to improve the quality of existing soil rather than replacing the soil with topsoil at a potentially higher cost. The results of previous studies show that landscapers are aware of the benefits of compost produced from organic materials (2). However, landscapers have expressed concern that compost from yard trimmings may contain harmful amounts of viable seeds, herbicides, and pesticides. Following proper composting procedures, making results of laboratory tests demonstrating the safety of yard trimmings compost available to landscapers should alleviate these concerns. Other factors affecting the use of compost in the landscaper industry include product availability, distribution channels, and cost.

The commercial landscape industry operates such that the materials used should, at a minimum, meet the specifications of the landscape architect or inspector.

Nursery Industry

Similar to the landscape industry, the potential for using compost in the nursery industry is greatly dependent on the economy and the housing industry. Home sales have a direct effect on the demand for nursery products (2). In addition, quality of the compost product, as well as its availability, distribution channels, and cost, can have an impact on the utility of compost in the nursery industry.

Use of compost in potting mixes helps to retain water, improve soil texture, and provide nutrients. Relatively inexpensive compost could be a favorable alternative to the more expensive, oftentimes imported, peat currently used in many areas of the country. To displace peat in any quantity, laboratory analyses and field tests would need to be conducted to demonstrate the benefits, safety, and reliability of compost for use in potting mixes.

Bare roots nurseries offer excellent potential for the use of compost. Other potential markets in the nursery industry include forest seedling nurseries, greenhouses, and Christmas tree farms.

Public Agencies

Public agencies have the potential to use both high-quality and low-quality composts. High-quality compost can be used in areas where humans and/or animals may come in contact with the materials (e.g., parks and playing fields). A lower-quality, relatively stable compost may be suitable for land reclamation, fill material, and landfill cover.

A study conducted by the City of San Jose identified uses where the demand for compost could be increased or created by the City (12). Among the uses are:

- parks and redevelopment;
- weed abatement on public lands;
- land upgrade; and
- roadway maintenance and median strip landscaping.

The use of compost in parks is mainly as a turf builder and maintainer. Compost helps maintain proper turf conditions on lands of high use such as recreation areas. Weed abatement can be achieved by using coarse compost that has low water retention. Vacant public lands can be upgraded with the addition of high-quality compost. Upgraded land requires less water to irrigate, has an increased resale value, and the quality of the soil is increased. The land can then be used for community gardening or leased to commercial nurseries. Compost may be used in landscaping to control weeds and improve soil conditions, and also as a landfill cover. An additional use can be in landspreading for reclamation programs. Some of the beneficial effects of landspreading include a more favorable soil pH and increased organic matter and nutrient levels (3).

Residential

The residential segment represents a substantial market for soil amendments. In order to market compost successfully to the residential sector, the public needs to be informed about the uses and benefits of compost, especially with the growing interest in organic gardening (13) . A marketing study conducted in Portland, Oregon showed that people are concerned about the safety of using compost (2). Some of the concerns most frequently mentioned were:

- disease transmission;
- contamination, chemicals, hazardous waste;
- harmful to children or pets;
- harmful to plants;
- dislike of garbage in yard;
- odors;
- insects;
- health concerns; and
- appearance.

To the extent that these types of concerns or perceptions hamper compost market development efforts, they should be addressed (see Chapters 5 and 6).

Results of the Portland marketing survey showed that of those individuals not currently using compost, more would be willing to use compost made from yard trimmings (45 percent) than from mixed MSW (38 percent) (2). The amount of compost that the residential segment indicated they would use would be largely dependent upon public education and the ability of the facility to produce a product that was of consistently high quality. Other factors that can affect the quantities of soil amendments used are their use regulations, distribution channels, distribution form (bulk or bag), availability, cost, population growth, the economy, and the vitality of the housing industry. Additionally, areas with a large percentage of single-family homes generally have a greater demand for soil amendments than areas of high-density housing. Public awareness of the benefits and limitations of compost will affect how much compost the residential sector will use.

Chapter 3

REFERENCES

1. de Lauzanne, R. "Methodologies and Technologies in Compost Production: The French Experience." Presented at the International Symposium on Compost Production and Use. S. Michele All'Adige (Trento), Italy. June 1989.

2. Cal Recovery Systems, Inc. Portland Area Compost Products Market Study. Prepared for Portland Metropolitan Service District. Portland, Oregon. 1988.

3. Mays, D.A. and P.M. Giordano. "Landspreading Municipal Waste Compost." BioCycle, 30(,3):37-39. March 1989.

4. Kubota, H. and K. Nakasaki. "State of the Art of Compost Systems: The Current Situation and Future Outlook in Japan." Presented at the International Symposium on Compost Production and Use. S. Michele All'Adige (Trento), Italy. June 1989.

5. Shimell, P. "Refuse Derived Compost Boosts Vineyard Yields." World Wastes, 26(11):8-9. November 1983.

6. Levasseur, J.P. "Household Refuse Recycling in France." BioCycle, 29(6):32-33. July 1988.

7. Porter, C. "French Farmers Favor Cordon Bleu Compost." Surveyor, pp. 14-16. September 1981.

8. L'Hermite, P. "State-of-the-Art of Compost Systems: Current Situation in Europe and Future Outlook." Presented at the International Symposium on Compost Production and Use. S. Michele All'Adige (Trento), Italy. June 1989.

9. Robotti, A.; G. Ramonda; A. Nassisi; A. Rattotti; and A. Barilli. "Optimization of Composting Process Utilizing Urban and Agricultural Wastes." Compost: Production, Qualitv and Use, pp. 666-675. M. de Bertoldi; M.P. Ferranti; P. l'Hermite; and F. Zucconi, eds. Elsevier Applied Science. 1987.

10. M.M. Dillon and Cal Recovery Systems, Inc. Composting: A Literature Study. Prepared for Ontario Ministry of the Environment. 1989.

11. Cal Recovery Systems, Inc. Composting Technologies, costs, Programs, and Markets. Prepared for U.S. Congress Office of Technology Assessment. Washington, D.C. 1989.

12. Yard Waste Composting Implementation Plan. City of San Jose. Office of Environmental Management. 1988.

13. Derr, D.A.; M.C. Varner; and G.J. DiLalo. "Marketing Potential of Organic Based Fertilizers." BioCycle, 25(3): 42-45. April 1984.

Chapter 4

FACTORS PERTINENT TO DEVELOPING COMPOST MARKETS

INTRODUCTION

This chapter examines factors that should be considered when developing and/or expanding compost markets. Pertinent factors are specifications for compost labeling, testing requirements, distribution methods, and policies such as guidelines or regulations, which affect developing and/or expanding compost markets.

COMPOST SPECIFICATIONS

Composting research and experience gained in producing and developing markets for compost show that consistent quality is very important to its marketability. Compost quality can be defined by a set of specifications. However, rigorous sets of specifications have not been uniformly developed for composts and soil amendments, in general. A few State agencies, the U.S. Government, and other countries have developed or proposed regulations to control the use of soil amendments for specific applications produced from different composted organic materials.

Relevant experience and information found in the literature demonstrate that specifications for soil amendments could include a number of parameters from the following list, some of which are overlapping:

- organic matter content;
- water-holding capacity;
- bulk density;
- size distribution (i.e., particle size) ;
- nutrient content;
- level of non-toxic substances;
- level of potentially toxic contaminants;
- concentration of weed seeds;
- seed germination and root elongation;
- soluble salts;
- ratio of available carbon/nitrogen;
- pH ;
- color; and
- odor.

The level of importance of these parameters to the major compost market users discussed in Chapter 3 is provided in Table 4-1.

Table 4-1

LEVEL OF IMPORTANCE OF COMPOST QUALITY PARAMETERS FOR VARIOUS USES 1/

Parameter	Agriculture	Landscaping	Nursery	Public Agencies 2/	Residential
Organic Matter Content	2	2	1	2	3
Water-Holding Capacity	2	2	2	2	2
Moisture Content	3	1	1	2	1
Bulk Density	2	2	1	2	1
Porosity	1	1	2	1	1
Particle Size	2	2	3	3	2
Nutrient Content	2	2	3	3	2
Non-toxic Substances	3	3	3	3	3
Heavy Metals	2	2	3	3	3
Toxic Substances	3	3	3	3	3
Pathogens	2	3	2	2	3
Weed Seeds	1	3	2	3	3
Soluble Salts	3	3	3	2	3
Maturity	2	2	2	3	3
pH	2	1	3	2	2
Color	1	3	2	2	3
Odor	1	2	2	2	3

1/ Ranking: 1 -- less important; 2 -- important; 3 -- very important.

2/ These may change depending upon end use, e.g., athletic field versus landfill cover.

(continued)

Table 4-1 (cont.)

Sources: Cal Recovery Systems, Inc. Feasibility Evaluation of Municipal Solid Waste Composting for Santa Cruz County, CA. December 1983.

Cal Recovery Systems, Inc. Portland Area Compost Products Market Study. Prepared for the Portland Metropolitan Service District. Portland, Oregon. October 1988.

Cal Recovery Systems, Inc. in association with Wilsey & Ham Pacific, Inc.; C. Henry; Thomas/Wright, Inc. compost Classification/Quality Standards for the State of Washington. September 1990.

de Lauzanne, R. "Methodologies and Technologies in Compost Production: The French Experience." Presented at the International Symposium on Compost Production and Use, S. Michele All'Adige. Trento, Italy. June 1989.

Inbar, Y. and H. A. J. Hoitink. "Growth Media for Container-Grown Plants." Ohio State University, Ohio. Undated.

Maine Department of Agriculture. Standards for Compost Products. Food and Rural Resources. April 1990.

Warncke, D. D., and D. M. Krauskopf. "Greenhouse Growth Media: Testing and Nutrition Guidelines." MSU Ag Facts, Extension Bulletin E-1736. September 1983.

Organic Matter Content

One of the keys to soil fertility is its organic matter content. As a result, plant growth is improved. As discussed in Chapter 2, adding organic matter to the soil also improves its ability to retain moisture and withstand droughty conditions.

Water-holding Capacity

The structure and texture of a soil amendment play an important role in the capacity of the soil to retain moisture. The water-holding capacity of a soil is primarily a function of the concentration of organic matter and clay content of the soil.

The water-holding capacity of compost and other soil amendments is indicated by the data in Table 4-2. Increasing a soil's water-holding capacity can promote plant growth and help it withstand drought conditions.

Bulk Density

Bulk density of material is a measure of its weight per unit volume, e.g., pounds per cubic yard. The bulk density of soil amendments should not be specified without referring to the moisture content at which the measurement was made. Listed in Table 4-3 are the bulk densities of some soil amendments reported in the literature. If soils are too dense, i.e., too compacted, seedlings may not emerge and root growth will be impaired. Adding organic matter will reduce the soil's bulk density and improve plant growth.

Size Distribution

The size distribution of soil amendment particles has an impact on the storage, packaging, distribution, and utility Of the product. The size distribution of the individual particles that constitute a particular type of soil defines the texture and, therefore, affects the productivity of the soil. Texture determines porosity, permeability, and other parameters that are important for plant production.

The size distribution of the particles that make up a soil amendment depends upon whether, and to what extent, the material is subjected to size reduction, as well as the type or degree of processing (including pre- and post-processing). This is especially true with an amendment produced from yard trimmings, MSW, or forest by-products. Size distribution is important to the user -- some users demand smaller particle sizes than others. The results of size distribution analyses conducted on yard trimmings compost are presented in Table 4-4.

Table 4-2

WATER-HOLDING CAPACITY OF VARIOUS SOIL AMENDMENTS

Amendment	**Water-holding Capacity (percent dry weight)**
Quartz sand	28 1/
Clay loam soil	44 1/
Yard trimmings compost	110 1/ 2/
Yard trimmings compost	115-138 3/
Peat moss	1,057 1/

2/ Results of Portland's quarterly testing program.

Sources: 1/ Portland Metropolitan Service District. A User's Guide to Yard Debris Compost. Portland, Oregon. June 1989.

3/ Sound Resource Management Group, Inc. Cedar Grove Compost: User's Guide for Landscape Professionals. Prepared for Seattle Solid Waste Utility. 1991.

Table 4-3

BULK DENSITIES AND MOISTURE CONTENTS OF VARIOUS SOIL AMENDMENTS

Material	**Bulk Density (lb/cu yd)**	**Moisture Content (percent)**
Redwood sawdust	200- 350	10-15
Wood chips	400- 600	15-20
MSW compost	500- 700	25-35
Yard trimmings compost	700- 800	30-50
Biosolids compost	900-1,100	25-35

Table 4-4

SIZE DISTRIBUTION OF YARD TRIMMINGS COMPOST 1/

Screen Size:	l/3"	1/4"	1/5"	1/10"	1/25"	1/50"
Percent Passing:	95	85	78	60	34	20

1/ Results of Portland's quarterly testing program.

Source: Portland Metropolitan Service District. A User's Guide to Yard Debris Compost. Portland, Oregon. June 1989.

Nutrient Content

A top quality compost contains appropriate concentrations of nutrients for a given use. The nutrients must be in a chemical form so that they can be used by plants. Major plant nutrients are nitrogen, phosphorus, and potassium (N, P, K). Minor plant nutrients (i.e., micronutrients) include copper, manganese, iron, and boron. Examples of the concentrations of nutrients found in compost and in some competing/complementary products are presented in Table 4-5. Nutrient levels can be supplemented by blending compost with higher nutrient sources (e.g., dried blood, bone meal, and inorganic fertilizer) .

Level of Non-toxic Substances

The presence of some non-toxic substances may be considered contaminants. These substances can be objectionable due to reasons of public health and safety (e.g., glass shards) , environmental, or aesthetics (e.g., bits of plastic). The level of these substances considered acceptable will depend on applicable compost standards and compost uses and users.

Level of Potentially Toxic Substances

Composted yard trimmings, municipal organics, mixed MSW, and biosolids may contain substances that can be toxic to plants, animals, and humans. Some of these substances are toxic in very small concentrations. On the other hand, certain elements and compounds not only are tolerated, but also are required by plants.

Examples of the concentrations of heavy metals and other potentially toxic compounds found in composts from yard trimmings and mixed MSW (including with biosolids) are presented in Tables 4-6 and 4-7.

The data in Table 4-6 show that, with minor exceptions, the yard trimmings compost tested had the lowest concentrations of heavy metals. Although the information for mixed MSW compost is the result of only one test, it shows that the material had relatively higher concentrations of some metals. In particular, mixed MSW compost had the highest concentrations of cadmium, lead, magnesium, calcium, sodium, iron, and aluminum. The concentrations of metals in compost made from mixed MSW and biosolids were, for the most part, higher than the concentrations in yard trimmings compost (see Table 4-8 for a list of various State standards on heavy metal and PCB concentrations for compost uses).

Information on pesticides, herbicides, and other potentially toxic compounds is shown in Table 4-7. The data show that the yard trimmings compost contained some organophosphorus compounds and chlorinated hydrocarbons. As compared to yard trimmings compost, relatively high concentrations of PCBs were found in composts made

Table 4-5

EXAMPLES OF NUTRIENT CONTENT LEVELS IN COMPOSTS AND SELECTED OTHER SOIL AMENDMENTS
(Percent dry weight)

Nutrient	Peat 1/	Sawdust 1/	Bark 1/	Vermiculite 1/	Leaf Compost (Westchester County, NY) 2/
Nitrogen					0.62
Nitrate			0.004	0.02	
Ammonium	0.01			0.00	
Phosphorus	0.11	0.006	0.011	0.06	0.04
Potassium	0.04	0.09	0.11	0.23	1.11
Sulfur					0.23
Calcium	0.18	0.12	0.52		1.84
Magnesium	0.06	0.01	0.01		0.59
Copper					ND
Manganese					0.0374
Iron					2.67
Boron					0.0015
Zinc					0.0082

(continued)

Table 4-5 (cent.)

Nutrient	**Yard Trimmings Compost (Portland, Oregon) 3 /**	**Yard Trimmings Compost (Twin Cities, Minnesota) 4 /**	**Yard Trimmings Compost (Seattle, Washington) 5/**	**Mixed MSW Compost (Fillmore Co., Minnesota) 6 /**
Nitrogen		0.57-2.14	1.3-1.5	1.08
Nitrate	0.0002-0.0008		7/	
Ammonium	0.0003-0.0052		7/	
Phosphorus	0.0085-0.0171	0.08-0.44	0.35-0.50	0.35
Potassium	0.2062-0.3756	0.06-0.88	0.53-0.72	0.76
Sulfur				.49
Calcium	0.2504-0.4726	1.36-4.51	0.74-1.15	7.60
Magnesium	0.0566-0.0920	0.20-1.16	0.15-0.19	0.58
Copper	0.0002-0.0006	0.0008-0.0018	0.0004-0.0006	0.02
Manganese	0.0066-0.0300	0.0289-0.0583	0.0144-0.0158	0.03
Iron	0.0100-0.0412	0.1327-0.3848	0.0288-0.0310	1.32
Boron	0.0000-0.0001	0.0018-0.0082		
Zinc	0.0016-0.0042	0.0052-0.0167	0.0078-0.0094	.10

2 / Average of five samples.
3 / Results of Portland's quarterly testing program.
4 / Based on two sample sets taken at 11 sites in each of two years.
5 / Tested at 30-day intervals from initial curing through maturity (90 days).
7 / Soluble nitrogen ranged between 0.3-0.8%.
--: Indicates tests were not conducted.

(continued)

Table 4-5 (cont.)

Sources: 1/ Portland Metropolitan Service District. A User's Guide to Yard Debris Compost. Portland, Oregon. June 1989.

2/ Richard, T. and M. Chadsey. Croton Point Compost Site: Environmental Monitoring Program. Cornell University. Prepared for Westchester County Solid Waste Division. November 1989.

3/ Portland Metropolitan Service District. Yard Debris Compost Handbook. circa 1989.

4/ Schumacher, N.; M. DuBois; M. Martindale; C. Clapp; and J. Molina. "Composition of Yard Waste Composts Produced at Twin Cities Metropolitan Area Centralized Composting Sites." Soil Series #124. Department of Soil Science, University of Minnesota, St. Paul, Minnesota. 1987.

5/ Sound Resource Management Group, Inc. Cedar Grove Compost: User's Guide for Landscape Professionals. Prepared for Seattle Solid Waste Utility. 1991.

6/ Cal Recovery Systems, Inc. Portland Area Compost Products Market Study. Prepared for the Portland Metropolitan Service District. Portland, Oregon. 1988.

Table 4-6

EXAMPLES OF CONCENTRATIONS OF TOTAL METALS IN COMPOSTS
(Parts per million)

Compound	Leaf Compost (Westchester Co., NY) 1/	Yard Trimmings Compost (Portland, Oregon) 2/ 3/ A	Yard Trimmings Compost (Portland, Oregon) 2/ 3/ B	Yard Trimmings Compost (Twin Cities, Minnesota) 4/	Mixed MSW Compost (Fillmore, Co., Minnesota) 3/	Mixed MSW and Biosolids Compost (Delaware) 5/
Cyanide	0.08	0.15	0.08		0.49	2.5
Mercury		0.05	0.08		3.70	4.1
Arsenic		4.80	5.20		1.10	7.4
Cadmium	ND	0.80	0.80	0.2-0.6	4.80	3.2
Chromium	10.46	24.20	21.60	2.5-14.1	56	240.0
Nickel	10.08	21	22.70	3.5-14.1	32.80	296.0
Lead	31.70	72.90	71.50	10-128	913	508.0
Magnesium	5,900	2,500	2,600	2,000-11,600	5,800	3,200
Calcium	18,400	10,500	10,300	13,600-45,100	76,000	17,000
Sodium	2,300	200	200	61-563	4,700	2,142
Iron	26,700	13,500	15,000	1,327-3,848	13,200	11,900
Aluminum	33,800	7,800	7,000	1,179-3,198	5,400	
Manganese	373.76	396	3,390	289-583	340	490
Copper	19.14	25	42	8-18	190	300
Zinc	81.60	160	160	52-167	1,010	1,039

1/ Average of 5 samples.
2/ One sample; A and B represent composts from two separate composting facilities.
4/ Based on two sample sets taken at 11 sites in each of two years.
5/ Average of 32 samples.
ND: Not detected.
-: Indicate tests were not conducted.

(continued)

Table 4-6 (cont.)

Sources: <u>1/</u> Richard, T. and M. Chadsey. "Croton Point Compost Site, Environmental Monitoring Program." Cornell University. Prepared for Westchester County Solid Waste Division, Department of Public Works. White Plains, New York. November 1989.

<u>3/</u> Cal Recovery Systems, Inc. <u>Portland Area Compost Products Market Study</u>. Prepared for the Portland Metropolitan Service District. Portland, Oregon. 1988.

<u>4/</u> Schumacher, N.; M. DuBois; M. Martingale; C. Clapp; and J. Molina. "Composition of Yard Waste Composts Produced at Twin Cities Metropolitan Area Centralized composting Sites." Soil Series #124. Department of Soil Science, University of Minnesota, St. Paul, Minnesota. 1987.

<u>5/</u> Delaware Solid Waste Authority. "The Delaware Reclamation Plant." 1988. Fairfield Service Company. "Fairgrow Easy Reference Chart." 1989.

Table 4-7

EXAMPLES OF CONCENTRATIONS OF HERBICIDES, PESTICIDES, PCBs, AND PCP IN COMPOSTS
(Parts per million)

	Leaf Compost (Westchester Co., New York) 1/	Yard Trimmings compost (Portland, Oregon) 2/ 3/		Mixed MSW compost (Fillmore Co., Minnesota) 3 /	Mixed MSW and Biosolids Compost (Delaware) 4 /
		A	B		
HERBICIDE/ PESTICIDE					
Chlordane	0.0932	0.324	0.152	ND	ND
p'p'DDE		0.014	0.005	ND	ND
p'p'DDT		0.019	0.008	ND	ND
o'p'DDT		0.004	ND	ND	ND
Toxaphene		0.300	0.300	ND	ND
Aldrin		ND	0.007	ND	ND
Dieldrin		ND	0.019	ND	ND
Dursban		ND	0.039	ND	ND
Endrin			ND	ND	ND
Lindane	0.1810		ND	ND	ND
Malathion			ND	ND	ND
Parathion			ND	ND	ND
Diazinon			ND	ND	ND
Trifluralin		Present	Present	ND	ND
Casoron		Present	Present	ND	ND
Dalapon		<0.50	<0.50		
Dicamba		0.5-12.9	<0.50		
MCPD		<0.5	<0.50		
MCPA		0.5-7.1	<0.5-2.4		
Dichloprop		<0.5	<0.5-1.2		
2, 4-D	0.0025	<0.5	<0.5		
Silvex		<0.5	<0.5		
2,4,5-T		<0.5	<0.5		
2,4-DB		<0.5	<0.5		
Dinoseb		<0.5-1.0	<0.5-1.0		
Captan	0.0052				
PCBs		ND	ND	2.53	1.0-6.0
PCP		0.210	0.120	0.016	

ND = not detected/below detection limit.
Hyphens indicate tests were not conducted.
PCBs = Polychlorinated biphenyls
PCP = Pentachlorophenol

1/ Average of 12 samples.
2/ One sample; A and B represent composts from two separate facilities.
4/ Average of 32 samples.

(continued)

Table 4-7 (cont.)

Sources:

1/ Richard, T. and M. Chadsey. "Croton Point Compost Site, Environmental Monitoring Program." Cornell University. Prepared for Westchester County Solid Waste Division, Department of Public Works. White Plains, New York. November 1989.

3/ Cal Recovery Systems, Inc. Portland Area Compost Products Market Study. Prepared for the Portland Metropolitan Service District. Portland, Oregon. 1988.

4/ Delaware Solid Waste Authority. "The Delaware Reclamation Plant." 1988.
Fairfield Service Company. "Fairgrow Easy Reference Chart." 1989.

Table 4-8

EXAMPLES OF COMPOST STANDARDS FOR VARIOUS STATES
(Parts per Million)

State:	Florida	Florida	Florida	Florida	Florida	Florida
Feedstock:	YT/LM	MSW	MSW	MSW	YT/LM/MSW	MSW
Use: 1/	**U 2/**	U	L2	L2 3/	L4	L5
Mercury						
Cadmium	<15	15	<30	100	100	>100
Nickel	<50	<50	<100	500	500	>50
Lead	<500	<500	<1,000	1,500	1,500	>1,500
Chromium						
Copper	<450	<450	<900	3,000	3,000	>3,000
Zinc	<900	<900	<1,800	10,000	10,000	>10,000
PCB						
Part. size (mm)	≤ 25	≤ 10	≤ 15	≤ 25	≤ 25	
Foreign Material	<2%	≤ 2%	≤ 4%	≤ 10%	≤ 10%	
Maturity	Mature or Semi-mature	Mature	Mature or Semi-mature	Mature or Semi-mature	Fresh	

(continued)

Table 4-8 (cont.)

State:	**Minnesota**	**New Hampshire**	**New Hampshire**	**New Hampshire**
Feedstock:	**MSW**	**YT**	MSW	**MSW**
Use: 1/	U	U 2/	L1, L2 L3, L4 4/	L4 5/
Mercury	5		10	10
Cadmium	10		10	10
Nickel	100		200	200
Lead	500		500	500
Chromium	1,000		1,000	1,000
Copper	500		1,000	1,000
Zinc	1,000		2,500	2,500
PCB	1		1	1
Part. size (mm)	≤ 10; ≤ 16; ≤ 25		≤10	>10
Foreign Material	1.0%; 2.0%; 4.0%		≤2%	≤ 2 %
Maturity	Mature	Mature	6/	6/

(continued)

Table 4-8 (cont.)

State:	New York	New York	North Carolina	North Carolina	North Carolina
Feedstock:	Msw	MSW	MSW	MSW	MSW
Use: 1/	Ll, L2, L3, L4 4/	L1	U	L2	Ll, L4
Mercury	10	10	10	15	15
Cadmium	10	25	10	25	25
Nickel	200	200	200	500	500
Lead	250	1,000	250	1,000	1,000
Chromium	1,000	1,000	1,000	2,000	2,000
Copper	1,000	1,000	800	1,200	1,200
Zinc	2,500	2,500	1,000	2,500	2,500
PCB	1	10	2	10	10
Part. size (mm)	≤ 10	≤ 25 (if >10 and ≤ 25, then Use = L4)	≤ 25.6	≤ 25.6	≤ 25.6
Foreign Material	–		≤ 6%	≤ 6%	≤ 6%
Maturity	**7/**	7/	Mature or Semi-mature	Mature or Semi-mature	Mature, Semi-mature, or Fresh

(continued)

Table 4-8 (cont.)

1/ Use: U = Unrestricted distribution
L = Limited distribution:
1) Non-food chain crops
2) Commercial, agricultural, institutional, or governmental agencies
3) Public distribution
4) Land reclamation or landfill uses
5) Disposed of unless demonstrated that use does not endanger the public or the environment.

2/ Not subjected to testing; yard trimmings compost is assumed to meet limits for contaminants.

3/ Cannot be used where contact with the general public is likely.

4/ Cannot be applied to crops grown for direct human consumption.

5/ This "off-spec" compost can be used as a landfill cover if the only difference between this compost and the higher grade is that the particle size is > 10 mm.
However if any of the contaminant levels is exceeded, then the compost must be disposed of, even if the particle size ≤ 10 mm.

6/ Must be produced from a composting process with a minimum active composting and curing period of *90* days.

7/ Must be produced from a composting process with a minimum active composting and curing period of *50* days.

YT = Yard Trimmings
LM = Livestock Manure
MSW = Municipal Solid Waste
-: Not included in the standards

from mixed MSW and from mixed MSW with biosolids. Small concentrations of PCP were found in composts made from yard trimmings and mixed MSW.

Concentration of Weed Seeds

Prospective users of compost, particularly of yard trimmings compost, invariably are concerned about the presence of weed seeds. Even though, theoretically, weed seeds should be killed by the heat generated during the composting process, composts should be tested periodically for viable weed seeds, and the results reported.

Seed Germination and Root Elongation

Seed germination and root elongation are used as indications of the stability of the soil amendment. Generally, seeds of timothy or water cress are used in this test.

Soluble Salts

Excessive levels of soluble salts can deteriorate the soil and be harmful to many types of plants, especially if the salts accumulate in the soil. On the other hand, the leaching of excessive amounts of salt may be a concern to local ground water supplies.

Ratio of Available Carbon/Nitrogen

As discussed in Chapter 2, the ratio of available carbon-to-nitrogen of 15-20:1 generally indicates a stabilized compost, although the significance of this ratio is dependent on the material(s) composted and the C/N ratio prior to composting.

pH

In a composting operation, it is not necessary to adjust the pH level of the composting material. Generally, the pH level drops at the beginning of the composting process, at times to as low as 4.5 to 5.0. After a few days, the pH begins to rise, and eventually reaches levels of 8.0 to 9.0. Unless the material being composted is unusual, the pH of the finished compost will be in the range of 6.0 to 8.0-9.0.

Color

The composting of practically every type of organic material results in a darker color as the process advances. The organic component of MSW, for example, changes from grayish green to black. Similarly, wood chips, sawdust, and yard trimmings are darkened due to the adsorption of the heavily pigmented humic acids. In some cases, producers of soil amendments add a compound specifically designed to darken the finished product.

A deep, dark material is typically associated with stability, maturity, and a high concentration of-organic matter.

Odor

Odor is a crude but effective means of monitoring the status of the composting process. In a well-run operation, the characteristic odor of the material being composted generally disappears after a few days. The sequence of odors generated by composting yard trimmings and MSW can often begin with foul odors, which are followed by a period of aromatic smells, and ends with earthy odors. Sometimes the earthy odors are preceded by the odor of ammonia. The persistent presence of a strong earthy odor is a good (but not absolute) indication that the composting process is completed, and that the compost is mature.

Specifications for Bark Products

The National Bark and Soil Producers Association (NBSPA) was established in 1971. The NBSPA is a non-profit organization that was established to represent professional processors and packagers of bark mulch and soil products. One of the primary objectives of the NBSPA is to assist the industry and its customers in defining quality products. As such, the organization developed categories and product nomenclature for bark and soil. The categories and nomenclature are presented in Table 4-9. As indicated by the table, the specifications are limited to the definition of size distribution and concentration of cambium and wood. In addition, the Association has developed its own logo. Permission to use the logo on packaged products is granted only to those processors who comply with the specifications listed in the table.

Shredding woody materials can produce various grades (e.g., fine and coarse) of mulch. The composting process can be used to prepare woody and vegetative materials into a better mulch product, and in less time, than it would take to produce a humus product (i.e., a mature compost). With the high temperatures achieved in composting, weed seeds and plant diseases can be inactivated or killed. In addition, the decomposition will darken the color of the mulch produced, and more closely resemble commercially available grades of mulch (l).

Examples of Compost Standards

To protect public health and reduce potentially harmful environmental impacts, some States and Federal agencies, as well as other countries, have established regulations and guidelines controlling the use of composts. Examples of the regulations and guidelines are given in Table 4-8 for five States in the U.S.

Table 4-9

CATEGORIES AND NOMENCLATURE OF BARK AND SOIL PRODUCTS

1.	**Decorative Bark Products:**	Consisting of Products mechanically screened for uniform size and containing cambium or wood content equal to 15 percent of less of total product weight.
A.	Southern Pine Bark Nuggets:	Particle size ranging from 1.25 inches to 3.50 inches in diameter.
B.	Southern Pine Mini-Nuggets:	Particle size ranging from one-half inch to 1.5 inches in diameter.
C.	West Coast Large Bark:	Particle size ranging from 1.75 inches to 3 inches in diameter.
D.	West Coast Medium Bark:	Particle size ranging from one-half inch to 2 inches in diameter.
E.	West Coast Pathway Bark:	Particle size ranging from one-fourth inch to one-half inch in diameter.
2.	**Bark Mulch Products:**	Consisting of products mechanically screened or shredded with cambium or wood content limited in accordance to the terms set forth, below:
A.	Southern Pine Mulch:	Particle size less than 1.5 inches in length.
B.	West Coast Bark Mulch:	Particle size less than one inch in length.
C.	Hardwood Bark Mulch:	Particle size less than 3 inches in length with cambium and wood content equal to 15 percent or less of total product weight.
D.	Cypress Mulch A:	Particle size less than 3 inches in length with wood fiber content equal to 15 percent or less of total product weight.
E.	Cypress Mulch:	Particle size less than 3 inches in length.

Source: National Bark and Soil Producers Association. "Uniform Nomenclature for Bark Products." 1989.

The Council of European Communities! compost regulations are listed in Table 4-10.

COMPOST TESTING REQUIREMENTS

Developing compost markets, particularly those produced from yard trimmings, MSW, and biosolids, is also affected by the type of product testing program established. The type, frequency, and results of the tests can afford a certain degree of comfort to the user. On the other hand, numerous and excessively frequent tests can be financially prohibitive.

Although procedures for testing the parameters listed above exist, a standard procedure for testing composts has not been established across the U.S. Some government agencies that encourage composting, such as the Metropolitan Service District in Portland, Oregon, have established and are financing a testing program. Tests are conducted on a quarterly basis. Some private organic material processors and producers of compost conduct their own tests and guarantee levels of nutrients and other constituents.

The tests that are most commonly conducted are those developed for determining the concentration of plant nutrients and potentially toxic compounds to plants, humans, and animals. Some entities also are testing for maturity by using growth germination tests and root length. Tests are also conducted for the presence of viable weed seeds. The methods followed for conducting the tests are those that have been developed over the years in the wastewater treatment, soil, and agricultural industries.

In most cases, the tests are carried out by independent laboratories typically paid for by the compost producer.

COMPOST DISTRIBUTION

The method and cost of transporting the compost from the composting facility to the distribution center or to the user can play a critical role in the cost-effectiveness of the composting facility. Consequently, it is important to understand the various factors that influence transportation. Some of the terms commonly used in the transportation industry and that will be used in this section include:

- Consignor: the party that has something to ship;
- Carrier: the hauler (trucking company, railroad, barging company, etc.) ;
- Consignee: the individual to whom the material or goods are shipped;
- TL : truck load;

Table 4-10

**COUNCIL OF EUROPEAN COMMUNITIES (CEC'S)
PROPOSED PHYSICAL AND CHEMICAL PARAMETERS FOR MSW COMPOST
APPLIED TO AGRICULTURAL SOILS**

Element	Recommended (mg/kg dry wt.)	Mandatory (mg/kg dry wt.)
Mercury	5	5
Cadmium	5	5
Nickel	50	100
Chromium	150	200
Copper	300	500
Lead	750	1,000
Zinc	1,000	1,500

	1987 Values	Target Values
Minimum Organic Matter (% drywt.) 1 /	30	40
Maximum Particle Size (mm) 1 /	24	24
Minimum Detention (days) 1 /	Variable	Variable
Maximum Moisture Content (%) 1 /	40	40
Maximum Inerts (% of drywt.) 1 /		
Glass	4	2
Plastic	1.6	0.8

Minimum Mineral Content (% of dry wt.)	Minimum Admissible Levels
Nitrogen	0.6
Phosphorus	0.5
Potassium	0.3
Calcium Oxide	2.0
Calcium Carbonate	3.0
Magnesium Oxide	0.3
Carbon/Nitrogen Ratio	<22 2 /
Conductivity	<2 g salt/liter (NaCl)
pH	5.5-8.0
Allowable Uses	3 /

(continued)

Table 4-10 (cont.)

Note: This is a partial summary. Refer to regulations for additional or complete requirements.

1/ Data reported represent 1987 values for medium grade compost; other grades include very fine, fine, and coarse.

2/ Applicable when starting materials have C/N ratio of 35-40 or slightly above.

3/ Allowable uses depend on the stage of stabilization, ranging from fresh organic matter (e.g., unsuitable for agricultural use, but possible substrate for composting, preparation of mushroom compost, etc.) to cured compost (e.g., safe for agricultural use).

Source: Zucconi, F. and M. de Bertoldi. "Specifications for Solid Waste Compost." BioCycle. 28(5):56-61. May/ June 1987.

LTL : less than truck load; and
STN : short tons (2,000 pounds) .

Freight rates are commonly based on two major criteria: cost and value of service. Cost is influenced by several factors including:

- distance;
- shipping weight;
- propensity to be damaged;
- insurance costs;
- potential to damage other commodities;
- propensity for combustion or explosion;
- ease or difficulty in loading and unloading;
- stowability;
- excessive weight;
- excessive length of trip; and
- frequency and regularity of shipment.

Once these factors are assessed as to how they affect the cost of transporting, the carrier considers the value of service. The demand for the transportation service is assessed and priced accordingly.

Transporting recycled materials, in particular compost, introduces additional complexities. Concern for the cost of shipping a low economic value material arises. In some cases, the shipping costs may exceed the economic value of the material being shipped. Also, since recycled materials often compete with virgin materials for markets, the freight rate structure could inhibit the efforts of this and other types of recycling by charging more. Furthermore, classifications stemming from a definition of the nature and composition of the material can complicate rate setting and can serve as a barrier to developing compost markets.

For motor freight, a commodity is classified according to the National Motor Freight Classification (Classification Description) . According to this classification, compost is classified as soil, implying a low value. There are two class rates for compost: Class 50 LTL and Class 35 TL. The minimum weight used to determine rates for the material is 40,000 pounds.

A few States, such as Minnesota and North Carolina, have given compost exempt status from standard classifications, deregulating, and thereby reducing, the cost of transporting compost. Reduced transportation costs will expand compost market development.

Rates for the transportation of compost and other soil amendments via motor carrier generally are filed at the Public Utilities Commission (PUC) or similar entity of each State.

Motor Carrier

<u>Bagged Compost</u>. The rates usually are flat rates for a 24- to 25-ton truckload. Additional stops are charged at $25-$70 each. The rates also include a certain amount of time for loading and unloading (about one hour for each task). Additional time requirements for loading or unloading are charged at about $50 per hour. There is a fee on the order of $25 per load for placing a tarp over the vehicle's contents.

Typical costs for intra- and inter-State transportation of bagged compost are presented in Figures 4-1 and 4-2. The graphs in the figures show that the cost for the intra-State transport is slightly lower than that for inter-State transport. Furthermore, as expected, the rates are relatively high for short trips, on the order of $0.13-$0.70 per ton-mile for trips from 6-50 miles. The rates decrease to about $0.05 per ton-mile for hauls on the order of 300 miles or longer.

<u>Bulk Compost</u>. Tariffs for the transportation of bulk compost have not been established in most States. Estimates of the rates for transporting bulk compost can be made by using rates charged for transporting topsoil or composted biosolids as a proxy for transportation rates for compost.

Topsoil or composted biosolids often are transported in large dump trucks or in transfer trailers. These vehicles can haul from 20 to 50 cubic yards of material. Charges are assessed on an hourly basis, and range from $35-$60 per hour. A cursory nationwide study of rates for transporting compost show that the rates vary from about $0.08-$0.47 per ton-mile for hauls of 50 miles or less. The rates fluctuate from $0.60 to $0.32 per ton-mile for distances of 20 to 100 miles and decrease to about $0.05 per ton-mile for distances over 150 miles.

Railroad

Commodities shipped by rail are described in the Federal Standard Transportation Commodity Code. Compost is not specifically listed in the Code, but potting media and peat are listed.

There are not many documented instances when potting media or any other similar material have been transported by rail. In one particular case, bagged material was transported about 200 miles. The rate was $47 per ton for a minimum load of 20 tons, a rate equivalent to about $0.24 per ton-mile. This rate is more than four times as high as the cost of shipping a similar distance by motor carrier.

Estimates for shipping 60-ton loads in box cars and 90-ton loads in hopper cars range from $11-$17 per ton. These estimates

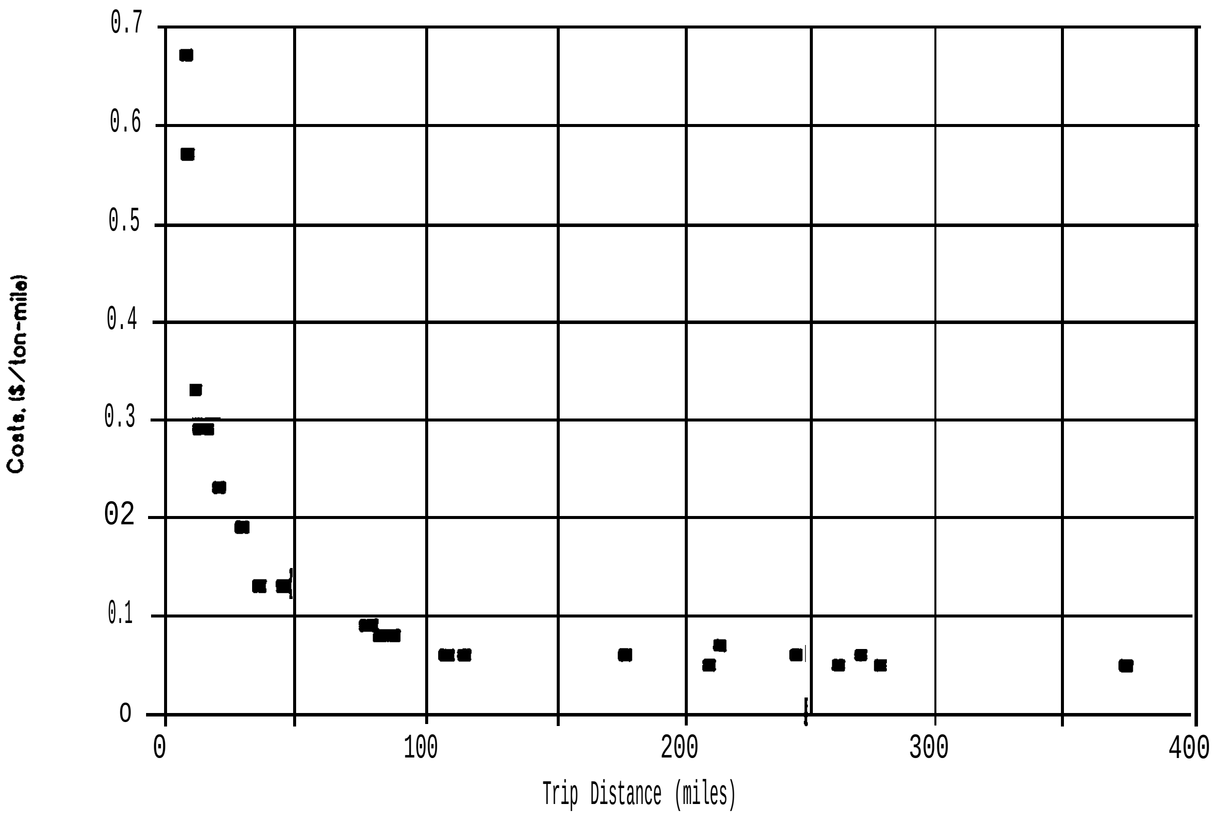

Figure 4-1. Intrastate motor carrier rates for bagged compost (point of origin: Portland, Oregon)

Source: Cal Recovery Systems, Inc. Portland Area Compost Products Market Study. Prepared for Portland Metropolitan Service District. Portland, Oregon. 1988.

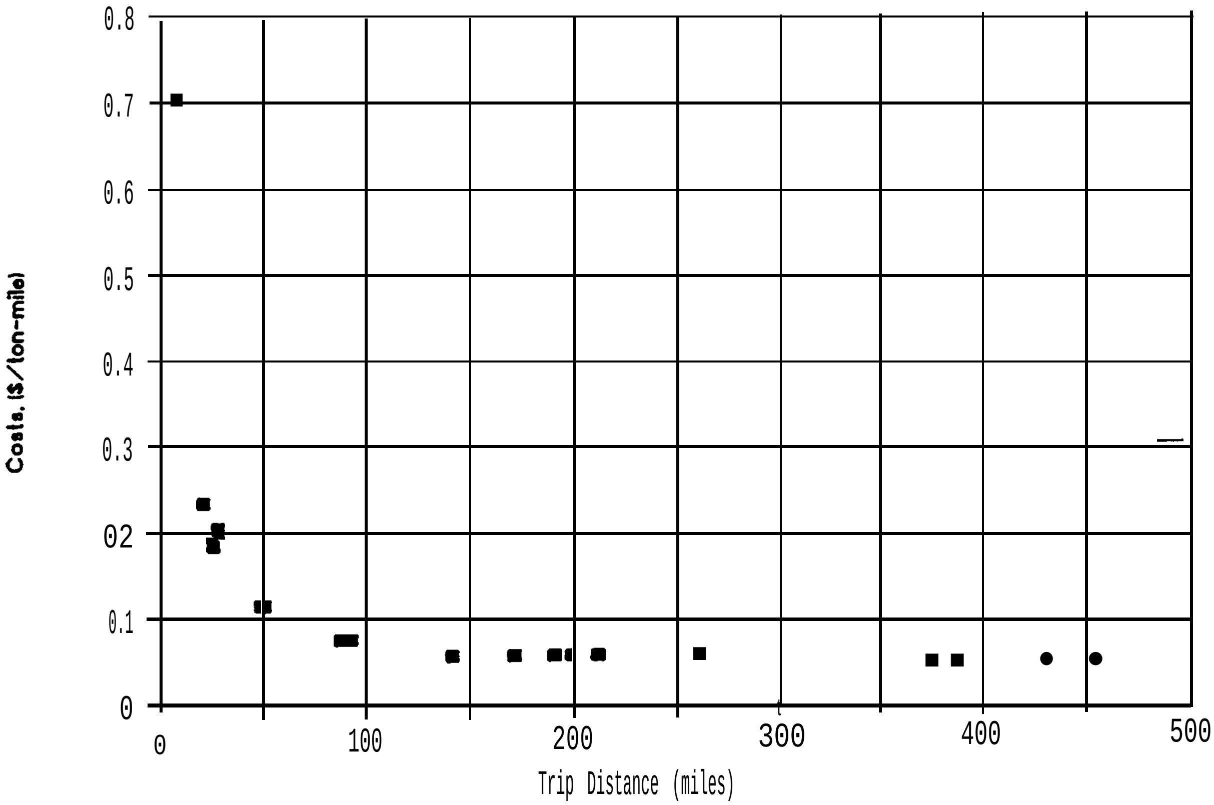

Figure 4-2. Interstate motor carrier rates for bagged compost (point of origin: Portland, Oregon)

Source: Cal Recovery Systems, Inc. Portland Area Compost Products Market Study. Prepared for Portland Metropolitan Service District. Portland, Oregon. 1988.

do not include loading and unloading or any additional transportation that may be required at either end of the trip.

Representatives of railroad corporations have indicated that it is unlikely that rail transport would be more competitive than trucks for trips under 100 miles. Generally, a railroad corporation must have a serious commitment from the customer before it files with the PUC for a new intrastate commodity rate. Railroad class rates for materials for which a commodity rate has not been filed typically are higher than those for motor carriers.

Shipping

In some instances, it may be possible to transport compost by ship. The shipping can take place in containers or in bulk.

Containerized Cargo. If compost were to be shipped by container, it would likely be placed in a 20 by 8 by 8 foot ("20-foot") container with a 20.5 ton weight limit. Although 40 by 8 by 8 foot containers are also available, the compost would exceed the weight limit before the container was full. Assuming a bulk density of 800 pounds per cubic yard for compost, about 19 tons would fit into a 20-foot container.

An official from the Port of Portland (OR) estimated that the cost of shipping compost would likely be more than $1,100 per container to Korea and possibly more than $2,000 per container for other destinations such as India and Saudi Arabia. This is equivalent to $58-$107.50 per ton. These costs do not include any inland transportation, loading and unloading charges, or possible "congestion surcharges" at the destinations (2) .

Bulk Cargo. The alternative to using containers is to transport the compost in bulk in the hold of a ship. This method appears to be less expensive than containerized shipping, although there are many variables which affect the cost. Assuming a total of 50,000 tons shipped annually in three equal shipments from the West Coast to Korea under current conditions, one steamship company estimated the cost at approximately $30 per ton (2). This rate assumes current market conditions and fuel prices. The rate includes loading and unloading, and assumes a loading capability of about 8,800 tons per day and a discharge capability of almost 2,800 tons per day. It does not include any inland transport.

The steamship transport market is highly volatile. Rates decreased approximately 50 percent between April and December of 1988. Backhaul rates on steamships are unlikely to be obtained for compost because little bulk cargo originates in the Far East destined for the U.S.

Based on current regulations, the present status of the transportation industry, and the value of compost, it is expected that transportation for bulk or bagged compost will be carried out primarily by truck. Proximity to waterways may allow the use of barges for U.S. transport. Transport of compost by rail may be competitive in cases where: 1) both the composting facility and the users are close to a railway; and 2) the distance between the facility and the users is more than 100 miles.

COMPOST POLICIES

In this section, the various types of policies and regulations that have been developed pertaining to compost purchase or use are grouped into three broad areas: 1) those affecting the environment and ‘public health and safety; 2) those affecting composting program implementation; and 3) those affecting distribution and use of the compost product. Many of the policies have only recently been developed (as of 1989) or are still in the developmental stages.

Policies that protect the environment and public health and safety are necessary to ensure a compost is safe to use. Policies that affect composting program implementation are needed to continue to encourage it as a municipal-level management alternative. Policies-that affect compost distribution and use are important to encourage market development of composts that are produced.

Environment and Public Health and Safety

When policies and regulations pertaining to composting are discussed, those that affect the environment and public health and safety are particularly important. Examples of these types of policies would be those that regulate the siting and operation of composting facilities and those that affect compost quality. Environmental and public health and safety regulations related to the composting of yard trimmings and MSW generally have been the responsibility of State and municipal governments.

Facility Control. Environmental and health and safety requirements for composting facilities are often covered by the regulations in effect for MSW disposal facilities. The primary foci of the requirements are that the facility be located in a environmentally suitable area, operated in a safe manner to protect the environment and public health and safety, and that nuisance control measures be taken when appropriate. Safety regulations in the U.S. include fire safety procedures, such as the provision of hoses and extinguishers around the piles and equipment. Nuisance control measures generally include vermin and vector control, noise and odor control, dust mitigation, and litter control procedures. The length of time that noncompostables are allowed to be stored on the facility grounds is often limited. Health and safety requirements at yard trimmings composting sites are less stringent and specific than those for mixed MSW composting since these facilities involve less machinery and handle generally less putrescible materials. Also, they have a much less likelihood of receiving household hazardous wastes.

Compost Quality. Compost quality is a function of the biological, chemical, and physical characteristics of the product. Efforts to regulate compost quality have approached the task in two broad ways: 1) regulating the process; and 2) regulating the finished product.

Control of the composting process begins with regulations pertaining to acceptable feedstocks. Incoming materials contaminated with hazardous materials are not generally accepted (nor desired) at facilities designed to compost yard trimmings or MSW for use as an organic soil amendment (3). Source separation of feedstocks, household hazardous waste collection programs, public education, monitoring of feedstocks, and preprocessing of the incoming materials are methods that can be utilized to limit the potentially hazardous materials entering the composting process.

Legislation passed by the States of Florida and New York provide examples of two approaches to controlling the feedstocks. The State of Florida has legislated that household hazardous waste, used oil, and materials containing asbestos should not be processed into MSW compost except for small quantities which might normally be found in household discards. It is the responsibility of plant operators to reject any loads found containing the household hazardous waste materials (4). Regulations have been developed by the State of New York to limit the amounts of household hazardous wastes entering mixed MSW compost by requiring that a household hazardous waste collection system be in place in any residential area serviced by a mixed MSW composting facility. The household hazardous waste collection system must be approved by the New York Department of Environmental Conservation and operated according to the State's Solid Waste Management Facility Regulations.

Utilization of proper composting methods, especially maintenance of high temperature levels, has been demonstrated to be effective in destroying pathogens. Similarly, maintaining proper temperatures during composting destroys weed seeds. At present, most regulations pertaining to composting methods have been developed for facilities handling biosolids. Some of these regulations have also been adapted to MSW composting facilities.

A number of States have developed compost quality standards which regulate compost products intended for distribution. Most of the standards were originally developed for biosolids compost, and adapted to yard trimming and MSW composts, although some are being developed specifically for this latter group of products. In addition, labeling standards could be developed so that users become aware of the product content and quality.

Regulations regarding the use of composted organic materials have primarily centered around the public health concern of possibly introducing potentially toxic compounds into the food chain. Heavy metals, PCBS, pesticides, herbicides, and other potentially toxic substances are present in some MSW and, consequently, can be present in the compost. If this compost is applied to the land or used as a growing medium in containers, some amounts of the potentially toxic compounds could be assimilated by plants and could possibly be transmitted to animals and humans consuming the crops.

Most compost standards, therefore, limit the concentrations of potentially toxic materials in the compost product. Regulations in some States (e.g., Florida) provide different sets of limitations depending upon the intended use for the product. Composts not meeting the most stringent limits for toxic materials may be restricted to use in non-food chain crops, or for land reclamation or landfill uses.

The State of Florida, in its draft regulations, has developed guidelines for compost products from yard trimmings, MSW, livestock manures, and biosolids. In addition to establishing limits for toxic materials, the State is setting standards for compost maturity, maximum particle size, and foreign material content. Standards for composts from yard trimmings and livestock manures in Florida are less stringent than those for composts from MSW and biosolids. It is assumed in the State that the concentrations of heavy metals in yard trimmings compost will be within the limits specified.

Although the kinds of policies discussed above were developed to protect the environment and public health and safety, they can also be a factor in the marketability of the compost product. A product that can be demonstrated to meet limits for concentrations of heavy metals, PCBS, herbicides, pesticides, etc., will be more readily accepted by potential users than one with unknown concentrations of these substances.

Composting Program Implementation

Policies encouraging the implementation of composting programs have had a major impact on the increase in the number of composting facilities. Examples of ways by which government agencies can increase the number of facilities and thus the volume of materials being composted are through the development of MSW management plans, by giving preference in the plans to composting over combustion and landfilling, by developing recycling goals, by banning disposal of yard trimmings in landfills, fostering siting of composting facilities, providing financing and tax breaks, and compost procurement guidelines. As a result of these programs, greater quantities of composts are produced and marketed.

An evaluation of the various policies and programs that can have an impact on composting has been carried out. The results of this 1989 evaluation are presented in Table 4-11. As shown in the table, most of the States in the Industrial, Midlands, Northeast, and Pacific regions have MSW management plans currently in place. In the Central region, only one State out of 14 currently has a plan, and in the South, only four out of 11. The method utilized to enforce recycling goals established by each State also varies. In the Northeast, most of the guidelines are mandatory and carry with them penalties for noncompliance. Conversely, in the other regions, the guidelines are mostly voluntary. The table also presents information regarding the regions in which composting, as a method to manage municipal organics, is higher on the municipal solid waste management hierarchy than combustion. Not noted in the table is the EPA hierarchy, where composting is higher in the hierarchy than combustion and landfilling. Although relatively few composting programs are in operation in the South region, composting is higher on the hierarchy than combustion as a MSW management method in over one-half of the States.

The State of New Jersey is an example of the effect policies can have on composting program implementation. It was the first State to ban leaves from landfills in 1988. The State now has the largest number of leaf composting facilities. Since then, a number of other States have passed similar laws, many of which are scheduled for implementation over the next few years (see Table 1-1). Some States have enacted laws that require source separation of yard trimmings (e.g., New Jersey and Pennsylvania).

Distribution and Use of the Compost Product

The need to protect the environment and public health and safety has resulted in policies being developed to regulate composting facilities and the quality of the finished product. The growing problem and expense with siting MSW management facilities has prompted policies aimed at increasing the number of composting facilities in operation and the volumes of organic materials composted. Among the three groups of policies being discussed, those affecting the distribution and use of the product are the least developed thus far.

As mentioned previously, because of its relatively low economic value and its low bulk density, the method and cost of transporting compost from the processing facility to the user is critical to the marketability of the product. Giving exempt status to compost for transportation can deregulate the rate charged for shipment, that, as explained previously in this Chapter, leads to reduced shipping costs.

Table 4-11

MUNICIPAL SOLID WASTE MANAGEMENT POLICIES IN THE SIX STUDY REGIONS (July 1989)

Category	Central	Industrial	Midlands	Northeast	Pacific	South
Number of States	14	8	5	7	3	11
Number with MSWM 1 / plans currently in place	1	7	5	7	2	4
Number planning to have MSWM 1 / plans in place within two years	2	1	0	0	1	4
Number of MSWM 1 / plans providing mandatory guidelines	0	1	1	4	0	1
Number of MSWM 1 / plans providing voluntary guidelines	3	7	4	3	3	7
Number which give composting higher priority than combustion	3	6	4	3	3	6
Number which ban landfilling of yard trimmings	0	3	4	1	0	2

(continued)

Table 4-11 (cont.)

List of States	AZ CO ID KS MT NE NV NM ND OK SD TX UT WY	DE IN MD MI NJ OH PA WV	IL IA MN MO WI	CT ME MA NH NY RI VT	CA OR WA	AL AR FL GA KY LA MS NC SC TN VA

1/ MSWM = municipal solid waste management.

Procurement policies that would give preference to purchasing or using compost, or recycled materials in general, in government-funded projects could significantly encourage use of the product. For some States, compost is considered a recycled material. In California, a State mandate was issued requiring all State agencies and departments to try to buy compost products if they meet State specifications and needs.

Policies regarding bid specifications for materials needed by governmental agencies can also have an effect on developing compost markets. For example, recent acceptance of yard trimmings compost as a soil additive by the New Jersey Department of Transportation increases the potential uses for the product by the State (e.g., in highway maintenance activities).

Chapter 4

REFERENCES

1. Lehmann, T.R. and J.P. Bradshaw, "Over 200,000 Tons Diverted Each Year." BioCYcle, 31(2):56-58. February 1990.

2. Cal Recovery Systems, Inc. Portland Area Compost Products Market Study. Prepared for Portland Metropolitan Service. Portland, Oregon. 1988.

3. Zucconi, F. and M. de Bertoldi. "specifications for Solid Waste Compost." BioCycle, 28(5):56-61. May/June 1987.

4. Criteria for the Production and Use of Compost Made from Solid Waste. Florida Department of Engineering Regulations. Workshop No. 2, Draft Regulations. May 1989.

Chapter 5

ECONOMIC AND NONECONOMIC BARRIERS TO DEVELOPING COMPOST MARKETS

While it is important to understand the characteristics of compost and the benefits from using compost, it is also necessary to recognize the barriers to developing and/or expanding markets for using compost. This chapter categorizes these impediments into economic and noneconomic barriers. By addressing these barriers (as discussed in Chapter 6), the benefits from using compost can be realized more easily.

ECONOMIC BARRIERS

Failure to Identify Potential Markets

Identifying potential markets for the compost product should be a top priority and ideally should occur prior to actually producing it. Identifying the markets is important because:

- quality requirements for the compost can be determined;
- multiple markets may require production of several grades of compost;
- projected amounts of various grades of compost can be estimated;
- pricing structures for various grades of compost and purchase levels can be established; and
- distribution strategies will help determine if bagging is needed.

Failure to identify markets may result in overproduction or underproduction of certain grades of compost. This can lead to excessive stockpiling and shortages of storage space, or, conversely, the inability to fulfill demand for certain grades of compost.

Cost Pressures from Competing Products

Compost must be priced competitively (or cheaper) than competing products. Manufacturers and retailers of competing products are likely to reduce the cost of their products, if necessary, to maintain their market share. In addition, competing products have a reputation for consistency and quality and are generally readily available. Therefore, if compost is not priced competitively with competing products, not demonstrated to be of equal or greater quality, and not available when needed, then its ability to penetrate existing markets will be impaired.

Post-processing Costs

Post-processing of compost (shredding, screening, blending/ mixing, bagging, etc.) , although intended to increase the value of the product, is a potential economic barrier to penetrating certain markets if it cannot be done cost-effectively. Post-processing increases production costs which must be recovered through increased revenues. It may not be necessary to post-process compost if the primary market is for land reclamation or as a landfill cover. On the other hand, if the market is nursery use, for example, then very specific post-processing steps may be desirable to remove unsightly, unwanted substances (e.g., plastic film) . Other favorable attributes of a compost for nursery use include freedom from potentially toxic substances, and suitable particle size distribution, maturity, water-holding capacity, organic matter concentration, etc.

Transportation Costs

The cost of transporting compost from the composting facility to the user has an important influence on successfully developing markets for compost. This is because compost has a low bulk density, and is a relatively low value material. Therefore, transporting compost over long distances may not be economically viable. Consequently, if prospective markets are far away from the composting facility, the cost of transportation could inhibit successful market development of compost. (For a detailed discussion of transportation costs, refer to the subsection “Distribution” in Chapter 4.) This relationship between distance and economic feasibility is a major and decisive factor in the market development of compost. The longer the distance a product must be transported, the greater is the cost of doing so. Ultimately, a Point is reached beyond which it is not economically feasible to transport the product.

Impacts of Competing Product Capital Investment

Not all equipment used for applying competing products is suitable for applying compost. Consequently, potential users of compost who currently use its competing products may have to make capital investments for equipment suitable for applying compost.

NONECONOMIC BARRIERS

Compost Quality Assurance

Although it could be argued that, theoretically, a demand for compost exists and only awaits to be tapped, the reality is that a sizeable part of this potential demand is for a grade of product higher than that of the “raw compost product." (The terms “raw product" and “raw compost" pertain here to yard trimmings or municipal organics that have been fully composted in the absence of special control measures and have not been post-processed, e.g., screened, for final disposition. This section deals with the "raw product," because most serious shortcomings are mitigated by the use of special separation and control measures and post-processing.) The key factor that prevents "raw compost" (both yard trimming and MSW compost) from meeting the requirements for the full spectrum of potential uses, and hence its full market potential, is insufficient quality assurance. Because yard trimmings typically make a better feedstock than do other municipal organics, this shortcoming is less serious with "raw yard trimmings compost" than it is with "raw mixed MSW compost."

Meeting the full compost market potential demands that the quality requirements established for three levels of use be met. Listed in order of diminishing quality needs, the three levels are: 1) horticulture (container nurseries, landscape contractors, greenhouses, home gardeners); 2) field-grown crops (row crops, field-grown nursery plants, sod); and 3) land reclamation and landfill cover. See Table 4-1 for the importance of compost quality parameters to the needs of these three markets.

Horticulture. The following is an example of the list of needs in the quality assurance category to be met in the production of a compost suitable for utilization in horticulture: 1) **consistency** in physical characteristics and chemical composition and concentration, and pH levels within the range of 6.5-7.5; 2) **absence** of particles larger than about one-half inch, weed seeds, substances inhibitory to plant growth, microorganisms pathogenic to plants and animals (including humans); and 3) presence of essential micronutrients, and C/N ratios between 10/1 and 25/1 (nitrate-nitrogen, NO_3-N, is preferable to ammonium-nitrogen, NH_4-N). These three groups of needs may not always be satisfied simultaneously in typical composting operations.

Field-grown Crops. Although the needs of field-grown crops are less rigorous than those for horticulture, they may not generally be met in typical composts. Reasons for the lower needs can be traced to the fact that soil serves as a buffer between plant roots and compost. There are three examples of needs which the typical composting process might not always be able **to** meet simultaneously. These are: 1) particle size less than one inch; 2) pH at 6.0-7.5; and 3) absence of toxic metals and resistant toxic organics.

Land Reclamation/Landfill Cover. Despite the relatively potential low quality and lack of quality assurance needs of compost for land reclamation and for covering landfills, these markets together may provide only a small fraction of the total market needed.

Compost User Attitudes

The attitude toward yard trimmings compost expressed in previous market development efforts and studies is generally more favorable than toward mixed MSW compost. An important factor is the perception that yard trimmings contain no harmful or objectionable components, and also tend to be source separated (see Tables 4-6, 7, 8 and 10). This favorable attitude also is fostered by the collective knowledge of experienced home gardeners. Concern about plant pathogens is minimal because of the perception that they are inactivated or destroyed in the composting process. There is some concern about pesticide residues. The concern is minimized because legal constraints have significantly reduced the use of persistent or particularly hazardous pesticides. Time and composting conditions effectively reduce and may even destroy the permitted pesticides. With respect to the possibility of weed seeds, most users are not aware of the fact that weed seeds are typically inactivated by the composting process and by routine product quality control (e.g., compost product testing).

Among large-scale consumers (e.g., agriculture, horticultural and greenhouse enterprises, and local and State agencies), and among some small-scale users (e.g., home gardeners), the present attitude toward mixed MSW compost may be characterized by a strong hesitancy. The hesitancy is the result of: 1) the collective justified and unjustified negative feelings of the public regarding mixed MSW composting; and 2) a considerable skepticism and uncertainty about the compost. The skepticism and uncertainty are due in part to the general lack of experience with the product. Because of this lack of experience, a record of continuity of supply and reasonable uniformity of quality currently is not available. The skepticism is further aggravated by the presently insufficiently defined quality assurance. As one example, skepticism leads to fear of losses from crop failure if the compost quality is inferior.

Worries and doubts are traceable to the nature of the feedstock used in mixed MSW composting and to the public perception that the material is likely to have harmful components that would become a part of the compost product. Only a long record of satisfactory experience can convert skepticism into one of neutrality, and then of a positive attitude. Considerable time may pass before that record is developed, especially with regard to large-scale users.

Locations of Markets with Respect to Compost Operations

The nature and characteristics of urban areas are such that, with some exceptions, the distance between potential users and composting facilities may be sufficiently great to exert a negative effect on compost use and the attendant market development. This situation arises, in part, from the logical tendency to site MSW management operations, such as composting facilities, as closely as is feasible to the generators. The situation with yard trimmings may be one of the few exceptions, especially those materials generated from landscaping activities and light agriculture (e.g., nurseries and truck farms) . In this case, if composting facilities are located close to these generators, potential compost users are likely to be in the vicinity.

Distance exerts two totally different types of effects on the use of compost. The first effect involves product acceptance and recognition. Acceptance and recognition of composting and using compost are necessary preludes to developing markets for the compost product. The second effect is intertwined with transportation -- bringing the product to the user.

proximity promotes awareness and recognition. Thus, a potential user is more likely to know of a compost product produced in his or her area than of one produced many miles away. This awareness is a very positive factor favoring the market development of the product, provided the composting facility is not associated with unpleasant factors, such as bad odors, traffic congestion, etc.

For the second type of effect, distance affects availability of the compost product. The greater the distance, the more the number of uncertainties. The number and seriousness of interferences and interruptions between production of the compost product and its delivery to the user increases with distance. More importantly, distance may determine the size of the potential compost market area and greatly influence the ability for market expansion. The greater the market area, the longer time it may take to reach the saturation point, i.e., the absorption capacity of the compost market increases. Furthermore, the larger the market area, the greater is the potential diversity of compost users and uses.

In addition, there may be an incompatibility between the urban area generation of organic materials and the oftentimes rural nature of potential large compost markets. The difficulty is in the fact that feed materials for the composting facility may mostly be of urban origin, whereas large users of the compost product often may be in a rural or agricultural setting.

Access to Transportation Routes

As stated earlier, access to transportation routes can become a barrier to developing compost markets because users of the product are not always in close proximity to the composting facility. Therefore, before the compost product can be marketed, it may need to be moved to distribution points that either are close, or are readily accessible, to the prospective users.

In keeping with the three applicable modes of transport, the transport routes for developing compost markets in bulk are highway, rail, and water. As described in Chapter 4, serious competition of rail with truck transport could only occur if changes were made to existing rail transportation policy. As for water transport, it may be viable only for communities sufficiently near navigable waters. Consequently, of the three routes, currently the highway is perhaps the most available and practical transportation route on a nationwide basis. Furthermore, with few exceptions, the product would have to be hauled from the composting facility to the railway or waterway by truck. The volume of product per shipment and whether it is shipped in bulk or package will determine the type and size of vehicle.

The barrier may be further magnified by doing the post-processing step(s) at a separate facility. This is more likely to be done if post-processing is expanded to include converting the compost product into various fractions designed to meet particular specifications for users in different areas (i.e., markets). Moreover, such an expansion may be more useful for broadening the market base of yard trimmings compost by providing more flexibility in the products and their markets.

The impact of this transportation barrier on the market development of MSW compost is much greater than that On the developing markets for yard trimmings compost, simply because the volumes of MSW compost involved are potentially much larger. However, in contrast to the greater potential production volume of MSW compost relative to yard trimmings compost, the actual current production of yard trimmings compost greatly surpasses that of MSW compost. Moreover, site restrictions and requirements for yard trimmings composting facilities are generally less extensive than MSW composting due to the different feedstocks and processing steps, and they may be easier to site closer to transportation routes.

Distribution of the MSW compost will most likely be confined to bulk deliveries and involve large-volume transportation. As a result, as stated earlier, access to adequate transportation becomes a decisive factor and, accordingly, lack of access can become a substantial barrier to the developing markets for MSW compost.

Comparative Availability of Compost

Although the number of yard trimmings composting operations far exceeds that of MSW composting operations, most of the individual facilities are comparatively smaller in Size and somewhat seasonal in operation. Currently, the availability of yard trimmings compost is highly localized. At present, the availability of compost satisfies its demand in many areas. The reason is that the extent of where yard trimmings are generated, and of gardening activity and associated use of composted yard trimmings, are somewhat interdependent. Long-term availability of compost is as yet somewhat uncertain, and will remain so until a sufficient number of composting facilities have been in operation for a reasonable length of time.

At present, the quantity of MSW compost on the market is extremely limited and the continuity of supply (i.e., long-term availability) is uncertain. This uncertainty reflects the current status of MSW composting in the U.S. That is, no existing MSW composting (excluding MSW co-composting) facility has been in continuous operation longer than a few years. As a result of this uncertainty, the long-term availability of MSW compost is far less assured than that of competing products, unless and until the MSW composting situation becomes better established.

Availability could also become a problem if use of high quality compost products was more vigorously promoted without a comparable increase in their production. On the other hand, an oversupply of compost could also develop, such as if large amounts of low quality compost were made and there were not enough low quality markets (e.g., landfill cover) available.

Procurement Policies for Compost

Procurement policies relative to markets for yard trimming and MSW composts are usually associated with those divisions of Federal, State, and local agencies, public and private institutions, large business enterprises, and other organizations that use and procure soil amendments in the performance of their landscaping and planting projects. These projects may range from planting, landscaping, and highway right-of-way maintenance, to land restoration and reclamation.

Usually the procurement policies applied are simple -- namely, buy those soil amendments that are least expensive, most readily available, have the most attractive and consistent properties, are most convenient to apply, and are under no apparent public or private prohibition. At present, compost may not be available in many areas to completely satisfy the soil amendment needs of these procurement agencies. However, with increased composting activity, compost will become more available. What needs to be determined is whether the compost will satisfy the other factors (e.g., users' quality requirements).

Restrictions on Compost Use

Various government restrictions on use of yard trimming and MSW compost products are based on their potential impact on public health and the environment. Particular restrictions are based upon the level of contaminants, the potential impact on soil, water, and air resources. Restrictions may be in the form of regulations, specifications, and standards imposed by Federal, State, or local agencies, or simply may be those dictated by sound resource management and by plant needs. The current Federal restrictions pertain mainly to biosolids compost. Restrictions act as barriers to compost use by way of placing limitations on the amount of individual application rates, frequency of application, and time span of an application program. Application limitations may also be established for a substance introduced by way of the product. Limitations on application rates based on the potential adverse impact on a water resource may be determined by the relation between the concentration of an available fertilizer element (e.g., N, P, K) in a soil plus that added by way of the compost and the amount required by a crop. Generally, fertilizer elements not used by a crop or otherwise immobilized in the soil are leached to the ground water, run off to the surface water, or volatilize.

Legal Constraints

Other than a general prohibition against false advertising (e.g., unfortified leaf compost marketed as a fertilizer), legal constraints are those that prohibit the production and distribution of any product which will exert an unduly adverse impact upon the environment and public safety and well being. It is only relatively recently that specific legal constraints have begun to be imposed by individual States. These constraints have been in the form of regulations regarding maximum permissible concentrations of certain heavy metals and persistent potentially toxic organic chemicals in biosolids compost. Standards regarding weed seed content and degree of maturity are beginning to be set by government agencies and private entities. However, State and Federal agencies have been directing their attention mostly to pathogen, heavy metal, and potentially toxic organic substance concentrations.

Constraints that have posed the most serious barriers upon compost use, and perhaps, thereby, compost market development, are those relating to heavy metals and resistant toxic organics. Because pathogens are substantially eliminated during the composting process, the possibility of pathogens being present has not constituted an insurmountable legal barrier. Federal biosolids regulations regarding pathogen kill should be satisfied by adhering to legal stipulations regarding attainment and duration of the high temperatures during the composting stage (l).

Legal constraints regarding heavy metals and toxic organics have restricted the use and consequent market development of biosolids compost. Mixed MSW compost use may be restricted to a lesser extent because it too can potentially contain heavy metals and potentially toxic organics, although generally to a lesser degree than does biosolids compost. Because contamination with heavy metals and persistent toxic organics is practically nonexistent in typical yard trimmings, very few legal constraints currently exist regarding the use of yard trimmings compost.

Another legal constraint occurs during inter-State marketing of compost. The problem is the lack of a uniform legal code (e.g., uniform definitions). As of now, regulations may vary from State to State. Because of distribution limits associated with transportation (e.g., distance -- discussed in Chapter 6), this constraint presently is not a great barrier, except perhaps in regions along State boundaries and in relatively small States.

Strategies to overcome economic and noneconomic barriers to increased compost market development are discussed in the following chapter.

Chapter 5

REFERENCES

1. 40 Code of Federal Regulations. Chapter 1 - Part 257, Appendix II. July 1, 1988 edition.

Chapter 6

STRATEGIES TO MITIGATE/OVERCOME BARRIERS TO DEVELOPING COMPOST MARKETS

In order to take advantage of the potential benefits of using compost (e.g., improving the soil, enhancing plant growth, and protecting water resources), economic and noneconomic strategies will likely need to be fostered and institutionalized at the local, State, and Federal levels (1) . For example, with passage of the 1990 Farm Bill ("Food, Agriculture, Conservation, and Trade Act of 1990"), there will be a greater role for the U.S. Department of Agriculture (USDA) in promoting the use of compost, especially by farmers and the public.

The Farm Bill's section 1456 ("composting Research and Extension Program") recognizes the potential soil, crop, and water quality benefits from using compost. According to section 1456, USDA will:

(1) make information on the potential uses of compost available to appropriate Federal, State, private authorities, and the general public;
(2) identify and compile information on State, local, and foreign government definitions and standards for processing, handling, and using compost;
(3) conduct research and an assessment of potential uses of composts produced "on" and "off" the farm, and markets for the compost;
(4) inform farmers and the general public on benefits of using, and methods for applying compost; and
(5) consider designating composting as a farm conservation practice eligible for cost-sharing.

While considering that economic and noneconomic barriers to developing compost markets may exist, the experience of many communities indicates that these potential barriers can often be overcome. This chapter discusses strategies to overcome these barriers, that will help to build successful programs to develop and/or expand compost markets.

OVERCOMING ECONOMIC BARRIERS

Identifying Potential Compost Markets

Identifying potential compost markets requires surveying the local area for those interested in its use and determining their potential needs as to compost quality and quantity. Diversification of compost products can increase overall market opportunities. This allows post-processing and other compost production factors (e.g., quantities of different grades of compost) to be adjusted to meet the markets' needs. Compost has been successfully marketed in bulk and bag. Bulk sales are typically for large volume users, and bag sales are typically for small volume-users. Therefore, there is no single "best" method to market a compost product.

All potential markets should be considered. In addition, new uses and applications may be found within a community that were previously ignored for various reasons, including the expense of purchasing suitable soil amendments. Also, by identifying uses of compost on public grounds and projects, communities can avoid the costs of purchasing other soil amendment products. Experience has shown that there are many beneficial applications for suitable soil amendment products within a community that compost can satisfy with very little (if any) additional cost and labor needed after it is produced.

Also , compost marketers can promote compost to producers and suppliers of competing/complementary products as a source of "raw material" or an ingredient for their products. For example, topsoil and potting soil producers can mix compost in with their products to improve the organic content and provide a modest supply of nutrients in the product. Properly cured compost would be a suitable ingredient for many competing/complementary products. In many cases, it may also be a cheaper input material. In many parts of the country, topsoil is essentially a seasonally available product. In other areas, adequate topsoil is simply not available nearby. Therefore, mixing compost into topsoil could extend existing supplies of topsoil and reduce the expense and need for transporting topsoil from relatively distant sources.

Overcoming Cost Pressures from Competing Products

Some communities have offered compost free or at reduced prices initially to attract users and markets. However, others in the composting industry feel this tends to devalue the product in the customers' mind (making it difficult to later charge a price) and recommend that it be sold at a positive price to cover at least some of the processing and/or transportation costs (2) . Whether or not a price is charged may also depend on whether the composting facility is a public or private operation (3). If a price is charged, a pricing structure can be established to reflect the purchase quantity and distribution method (3)(4). For example, a lower price can be charged to encourage customers to purchase greater quantities of compost or pick up the compost at the composting facility.

Recovering Post-processing Costs

Post-processing is generally performed to improve the quality and/or increase the value of the compost. This may be done to meet the quality needs of a specific market, increase the compost's ability to bear the cost of transportation, or simply to improve its salability. Post-processing costs are a possible barrier, but a potentially avoidable one if they are recovered through a higher selling price for the compost product. The key, here, is to recognize when and to what extent post-processing is necessary. This requires an understanding of specific markets' needs as to the characteristics of the compost (e.g. , particle size, pH, distribution method, etc.).

If bagging is being considered, an evaluation of the increased cost versus expected additional revenue should be performed. (As a rough guide, the average price in 1988 for peat sold in bulk was $18.14 per ton; for peat sold in packages or bales, the average price was $24.68 per ton [5]). Wholesale and retail distributors should be identified. Distribution networks may have **to** be established. Transportation modes and costs must also be considered.

Also, the effectiveness of source separation, the composting technology used, and the quality control employed will likely affect the need for, or level of, post-processing. Public education, separate collection containers, inspection of incoming compostable materials, and effective up-front facility separation can prove useful here.

Mitigating Transportation Costs

Various means are available for reducing the cost of transporting the compost product from the composting facility to its potential users. Favorable transportation rate structures for compost would potentially reduce its cost barriers and increase its use. Thus , adjusting transportation rate structures, such that if any rate inequities exist they are eliminated (or modified in favor of the compost product) , could have a significant impact on increasing compost use.

Shipping compost at lower backhaul rates is another method that can lower transportation costs. Generally, backhaul rates are set very low in many areas in order to utilize otherwise empty return trips, attract freight for return trips, rather than allowing vehicles to return empty to points of origin. Similarly, if compost feedstocks (more appropriate for source separated yard trimmings) are transported to a composting facility (especially one in a rural site), finished compost could be returned to urban markets or outlets in the same vehicles provided the vehicles are cleaned as appropriate (e.g. , to reduce transmittal of weed seeds to the compost).

It is also possible to increase the value of compost through post-processing (e.g., by shredding, screening, blending, and/or bagging) so that it is better able to bear the cost of transportation. This is currently done with many competing/ complementary products such as peat and potting soil. The bagged compost can be given a brand name to develop product identity and user loyalty. Benefits, uses, and instructions for the compost can be printed on the bag.

Another means to reduce transportation costs is to locate the composting facility at, or near, the primary users' location(s) . This is a viable alternative if a user (e.g., a nursery or farm) has suitable land area for the composting facility and this area complies with composting facility siting requirements. Various advantageous arrangements may then also be possible regarding provision of labor, equipment, and land.

Finally, most transportation costs can be avoided if markets are found and developed in the immediate local area. Often, one of the best markets for compost is within the community in which the yard trimmings or other municipal organics are generated. This includes uses in parks, landscaping, home gardens, etc.

Overcoming Impacts of Competing Product Capital Investment

This potential barrier may be difficult to overcome. Fortunately, it is not applicable to many of the potential markets for compost. The problem is that even with various incentives to purchase necessary compost application equipment, a capital outlay is required, possibly idling some already purchased equipment that was used for applying the competing product(s) . However, the equipment used with the competing product(s) may have other uses or resale value which allows some of the capital investment to be recovered.

Many States have enacted incentives to encourage the use of recycled materials, which may (or should) apply to the use of compost. These include consumption tax credits, sales and property tax exemptions, grants, and low interest loans. Tax incentives generally apply to local and/or State taxes. They are an inducement to invest in new capital but, by themselves, do not fully compensate for the cost of investment. The same is true with low interest loans. Grants will generally cover some or all of the cost for application equipment.

In addition, since this potential barrier typically applies to certain, perhaps large, users of compost, lower prices may be offered for substantial purchases of compost.

OVERCOMING NONECONOMIC BARRIERS

Providing Compost Quality Assurance

Two of the more important tasks, not only for developing a market for the compost product, but also for maintaining it, are to establish an acceptable set of compost standards and specifications and to ensure that the product unfailingly meets those standards and specifications. The latter task is particularly important because, as discussed in Chapter 5, deviations in quality lead to user frustration, and, with commercial users, possibly to financial losses. Moreover, it is the only way to build a favorable record.

Progress in identifying and implementing measures that improve compost quality assurance can be made by actively seeking involvement from potential users on their specific needs and biological, chemical, and physical qualities they believe are important or essential. Compost users that should be consulted include agronomists, farmers, home gardeners, horticulturists, nurserymen, landscape architects and specialists, municipal and State park officials, and university agricultural extension agents. However, the gardening market is strongly influenced by developments in horticulture-oriented industries. In addition to the users listed above, public health and environmental protection agencies and associated professionals should be included. Arbitrary decisions should be avoided in establishing specifications, standards, and directives.

Improving the quality of the "raw compost" product by screening is accompanied by an increase in the size of the rejected fraction and a lowering of the volume of marketable product. This problem could be resolved by grading and developing markets for the product into two or more quality levels, e.g., into top quality, medium, and general or noncritical use. Another gradation could be on the basis of unrestricted use (for all uses except perhaps food crop production); and restricted use (e.g., use only for reclamation of disturbed land areas or only as landfill cover). Several States have established at least one grade for compost, as well as standards and specifications to be met by each grade (see Table 4-9).

Improving Compost User Attitudes

To compete successfully with other soil amendment products, compost must be shown to be of equal or greater benefit and value. It is important to stress the benefits of using compost (e.g., plant growth improvement, erosion reduction and water quality benefits, and plant disease suppression). If a quality compost is consistently produced, over time it will be able to establish a positive reputation, such as that currently enjoyed by many competing products.

The prevailing attitude toward most composts is generally favorable. Not only have the many "virtues" of good quality compost been widely recognized and publicized, they have also been convincingly demonstrated in many areas. Compost demand can be further increased by educating new users on the benefits of using compost and providing application information (6) (7). For the present, once good quality compost has been assured, the next step will be to expand the magnitude of compost production so large quantities of compost are readily available and used.

There are two important aspects of developing markets for yard trimmings compost. The first is to maintain a favorable attitude toward it. An example of an action that could adversely impact users' attitudes would be the addition to yard trimmings of street sweepings that have been contaminated by glass shards, metals, and a variety of other objectionable items. This could adversely affect product quality and cause users to react unfavorably to the use of the contaminated product. A favorable attitude can be strengthened by applying quality assurance measures as discussed in Chapter 4. Furthermore, working with university agricultural and cooperative extension services and professional groups (e.g., landscapers, agronomists, and farm bureaus) to develop markets and providing the public and others with technical assistance can greatly influence compost product acceptance (4).

The second is to expand the production of yard trimmings compost to the highest level possible, while still ensuring the continued availability of, and markets for, the product. In addition to assuring a continuous supply, lists of suppliers and their addresses, compost delivery arrangements (if any) , and price could be made available to the public, landscapers, government agencies, and others who would use the product. For example, establishing a local telephone hotline to provide information on availability, location, price, and use of compost would be helpful in informing potential users.

Some users of mixed MSW compost have positive attitudes and others have negative attitudes towards its use. Generally, there currently seems to be more acceptance for its use for land reclamation or as a landfill cover than for higher grade uses. For marketers of compost to increase acceptance of the product, they need to ensure: 1) the product meets specifications/guidelines appropriate for the intended use; and 2) that sufficient quantities of the product are available for the intended use. This may be followed by an intensive educational program and the best use of promotion techniques (6)(7). Refinements to the product, when needed, must also be convincingly demonstrated so potential users are sufficiently reassured as to the improvements. Finally, the feasibility of making such a demonstration ultimately depends upon the guaranteed availability of a mixed MSW compost product that meets all specifications and standards.

Identifying Locations of Compost Producers and Users

Compost producers should take full advantage of the recognition factor that accompanies proximity to the composting facility and which is so essential to successful market development of any compost product. This can be done by properly operating the composting facility so it does not become a source of nuisances or adversely impact the quality of the environment in any way. Recognition can be furthered through the use of demonstration plots showing the beneficial effects of compost on plant growth and production. Another means is to arrange tours of the facility for the surrounding citizenry.

The negative effects of distance on availability can be mitigated by establishing a strategic network of distribution centers where an adequate inventory of compost is maintained. An additional recourse may be to expand the demand for the product to the fullest extent possible within the market area allowed by the distance between the site of the composting facility and the location of the users. Compost demand can be increased by finding additional uses for the product or by modifying it to meet new uses.

Near some of the larger urban areas, sufficiently large markets for compost may be further away in the rural areas. If this distance is too great, the cost for transporting the compost may impede the development of markets in these areas. As a rough guide, compost may be marketed within 40-50 miles from the compost processing facility (8)(9). However, the actual distance would depend on the quality and value of the compost, form of sale (i.e., bag or bulk), access to transport arteries, and type and size of transport vehicles.

Gaining Access to Transportation Routes

One approach to gain access to transportation routes is to site composting facilities at, or close to, the primary compost users, especially long-term, large users. Such locations could be near farms, nurseries, parks, landfills, etc. Siting must also take into account transport of the materials to be composted, as well as the relative costs of land to be used for the composting facility. As discussed above, strategically located compost distribution centers may be cost-effective in reducing transportation costs.

Increasing Comparative Availability of Compost

If the full potential use of yard trimmings compost could be realized, matching product availability with the seasonal demand for soil amendments could well become a problem. For the present, availability of yard trimmings compost in some cases is inadequate, at least as far as certain users are concerned; other areas are experiencing over-supplies of the compost. Very few retail outlets offer yard trimmings compost, whereas the potential demand for the product may be large. However, no such dearth of competing products exists. For example, cow manure, enriched bark compost, and peat may be available year-round.

Until more MSW composting facilities come into operation, availability will continue to be one of the barriers to developing markets for MSW compost. Since the characteristics of the products are likely to vary between facilities, it is difficult to make general predictions as to quality and utility. One would expect that quantities would be greatest in highly urbanized areas because of the proportionally greater volumes of organic materials generated and consequently larger composting facilities. Unfortunately, the potential use of the compost product in such areas may be able to accommodate only a small fraction of the total production capacity. Although it follows that unavailability would no longer be a problem, over- availability could become a serious one. Near relatively small cities, generation of the organic materials and the production of compost could be more compatible with that of demand.

Establishing Procurement Policies for Compost

procurement policies, public or private, that are biased against composts should be revised by policies unbiased or favorable to their use. Procurement policies can be implemented that mandate equal or preferential treatment of composted yard trimmings and municipal organics in the purchase of soil amendments and mulches. This type of policy generally provides that the compost in question be purchased and used if it is no more costly than competitive materials and if it meets all product specifications deemed essential.

Complying with Restrictions on Compost Use

The barriers "restrictions on compost use" and "legal constraints" are closely intertwined. Consequently, many of the statements made in this section could be applied to the following section and vice versa.

There are several State laws that restrict compost use (e.g., see Table 4-9). In addition, the EPA and many States have regulated the use of biosolids compost. These restrictions on compost use were generally imposed to prevent potential impacts upon soil, water, and air resources that could adversely affect public health, crop production, and overall environmental quality. Because with few exceptions these restrictions are based on demonstrated tests, first-hand experience, and objective analysis, any attempt to lessen them to facilitate market development for the compost product must be examined and evaluated with extreme care. It should be emphasized, however, that this does not preclude a continuing evaluation and critical examination of the restrictions by pursuing a program of careful research and reassessment of past experience and findings.

Recognizing Legal Constraints

As the state of knowledge regarding compost use advances, adjustments to compost use restrictions may be needed over time. Legal constraints on the use of a product or material should be based solely on the characteristics of that product and not whether it is a recycled product or virgin material.

Chapter 6

REFERENCES

1. Kashmanian, R.M.; H.C. Gregory; and S.A. Dressing. "Where Will All the Compost Go?". BioCYcle, 31(10):38-39, 80, 82-83.

2. BioCycle Staff. "The Present and Future of Compost Marketing." BioCYcle, 26(5):34-36. July/August 1985.

3. Cox, K. "Expanding Markets for Yard Waste Compost." BioCvcle, 29(10):64-65. October 1989.

4. Goldstein, N. "Marketing Strategy for Sludge Compost." BioCycle, 29(5) :42-43. May/June 1988.

5. Us. Department of Interior. Minerals Yearbook, Volume I: Metals and Minerals, 1988. 1990.

6. Derr, D.A.; M.C. Varner; and G.J. DiLalo. "Marketing Potential of Organic Based Fertilizers." BioCycle, 25(3):42-45. April 1984.

7. Goldstein, N. "He Brings New Life to Compost." BioCYcle, 26(5):37-38. July/August 1985.

8. Alexander, R. "Expanding Compost Markets.'! BioCYcle, 31(8):54-59. August 1990.

9. Cal Recovery Systems, Inc. Portland Area Compost Products Market Study. Prepared for Portland Metropolitan Service. Portland, Oregon. 1988.

Appendix A

EXAMPLES *OF* EXISTING PROGRAMS AND MARKETS

INTRODUCTION

Composting has become an attractive method in the U.S. to divert organic materials (especially yard trimmings) from disposal facilities and produce valuable end products. The number of facilities in operation, or in the planning or construction stages, is growing rapidly. The general status of yard trimming and MSW composting in the U.S. is discussed in the following paragraphs. Following that, information on the development of compost markets is presented for a number of existing composting programs. The information is divided by region, and is intended only to be representative of the many composting programs and their corresponding compost markets. The discussions are presented as an overview of the types of compost market development efforts in the Us.

Yard Trimmings composting

Composting yard trimmings has been practiced for many years in the U.S. However, it was not until the late 1980s that this practice began to attain widespread application. The following factors are particularly responsible for the growing interest: 1) recovery and utilization of yard trimmings is an effective means of diverting substantial quantities of organic materials from dwindling numbers of, and increasingly more expensive, landfills; 2) the material is easily composted; 3) the required technology can be minimal; 4) the regulatory requirements have not been too demanding; and 5) the value of the compost product.

Quantities of yard trimmings generated vary among regions. The size of the contribution of yard trimmings to a community's discards into disposal facilities. Results obtained in MSW composition studies show that yard trimmings may comprise from 5-30 percent (by weight). The relative contribution of yard trimmings is also a function of season, climate, vegetation, soils, population density, and affluence. Typically, the output of grass clippings and brush is greatest from late spring until mid-autumn. On the other hand, approximately 70 percent of the annual output of leaves is typically collected in the autumn.

Composting leaves collected in the autumn is currently the most frequent type of composting program in the U.S. (1) . These types of composting programs generally utilize a low-technology composting process. Market development efforts for leaf composting programs are usually conducted during a short time period in the spring and fall, because of the greater need for soil amendments at those times.

A trend in yard trimmings composting is towards implementation of more programs that process a mixture of yard trimmings (e.g. , leaves and grass clippings) during the year. These yard trimmings composting programs generally require higher levels of processing technology and more comprehensive compost market development programs. Tree trimmings and brush require chipping or shredding. In addition, improper composting of grass clippings can lead to the generation of offensive odors.

The compost product is a valuable soil amendment, provided it is free of objectionable, unwanted substances. It is a source of organic matter and a modest supply of nutrients.

Municipal Solid Waste Composting

MSW composting was given consideration as a management process in the U.S. as early as the 1950s. However, in the 1960s, several factors combined to discourage the prospects for MSW composting. The primary factors included: 1) an absence of a market for the compost product; 2) the very low cost of landfilling; and 3) the high carbon/nitrogen ratio of MSW in the U.S.

Composting municipal organics, as well as co-composting MSW with biosolids, currently is receiving a substantial amount of attention in this country. As of Fall 1989, seven full-scale MSW composting or co-composting facilities were in operation (2) . In addition, approximately 40 other facilities were in the planning, design, permitting, construction, or pilot-scale operation stage. Table A-1 presents a summary of these facilities by region.

With the current high degree of interest in MSW composting, institutions or agencies should also be cautious before implementing these programs. If a composting program is implemented without a full understanding of the MSW stream and the process itself, problems can be encountered during operation, in producing a high-quality product, and in developing compost markets. The quality of the finished product greatly depends upon the type, efficiency, and thoroughness of the separation process (including source separation), as well as process and product guidelines or regulations.

The seven full-scale MSW composting facilities in operation in the U.S. in 1989 are listed in Table A-2. Capacities of the facilities range from about ten to a few hundreds of tons per day. Little detailed information is currently available on the quantity or quality of the finished compost produced at most of these facilities. Their output of compost has typically not been sufficient to permit a long-term definition of the market for their respective products.

Table A-1

STATUS OF MSW COMPOSTING/CO-COMPOSTING FACILITIES IN THE U.S. (FALL 1989)

Region	**Consideration**	**Planning 1/**	**Operational**	**Total**
Central	0	4	0	4
Industrial	3	4	1	8
Midlands	10	16	4	30
Northeast	7	8	0	15
Pacific	2	3	1	6
South	4	6	1	11
Totals	26	41	7	74

1/ Includes planning, design, permitting, and construction stages, as well **as** pilot-scale or research facilities.

Source: Goldstein, N. "Solid Waste Composting in the U.S." BioCycle, 30(11):32-37. November 1989.

Table A-2

OPERATIONAL MSW COMPOSTING/CO-COMPOSTING FACILITIES IN THE U.S. (FALL 1989)

Location	Type of System	Material Added to MSW
Delaware		
Wilmington	In-vessel	Biosolids
Florida		
Sumter County	Windrow	None
Minnesota		
Fillmore County	Windrow	None
Lake of the Woods County	Windrow	None
St. 'Cloud	In-vessel/drum	Biosolids
Washington		
Skamania County	Windrow	None
Wisconsin		
Portage	In-vessel/drum	Biosolids

Source: Goldstein, N. and B. Spencer. "Solid Waste composting Facilities ." BioCYcle, 31(1):36-39. January 1990.

Composting Other Organic Materials

In addition to programs that compost yard trimmings and the other municipal organics, a number of programs have been established throughout the U.S. to compost other organic materials. Examples of these materials include horse manure, dairy manure, chicken manure, potato processing by-products, and seafood processing by-products. These types of programs are generally more limited in number and tend to be much more dependent upon the types of local industry and the types of organic materials these industries produce.

EXAMPLES OF COMPOSTING PROGRAMS BY REGION

Central

The Central region consists of the largest number of States (14) and has a total population of approximately 39,000,000. The States which comprise this region are: Arizona, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, Utah, and Wyoming.

The States in the Central region have the fewest active composting projects. This may be due to the fact that the region covers a large area of land that is not densely populated. In addition, the landfilling cost is relatively inexpensive and there is an absence of legislative measures discouraging landfilling. The Central region has a sizeable agricultural industry which could absorb compost products.

Boulder. Colorado. Boulder County and the City of Boulder have supported a wood chipping project since 1985. Woody material is collected during the regular "spring cleanup" program. The material is processed through a tub grinder and reduced to wood chips from one to three inches in size. During 1986, the project diverted 9,000 cubic yards of woody material from the landfill, and produced 3,250 cubic yards of wood chips (3)(4).

Lincoln, Nebraska. A program was begun in June 1988 to use "biodegradable" cornstarch plastic bags in the collection of yard trimmings for composting. The compost from the program's first year was unmarketable due to the presence of nondecomposed bag pieces, so it was spread on a closed landfill and disked in.

The City has an agreement with the University of Nebraska to conduct tests on the bags and the compost. The series of tests also include an analysis of pesticides and herbicides in the leachate. Local nurserymen, landscapers, and sod farmers have expressed an interest in using the compost (5).

Omaha, Nebraska. The City of Omaha is using a closed landfill as a site for a pilot-scale yard trimmings composting program. In 1987, the breakdown of the yard trimmings accepted was 60 percent leaves and 40 percent tree trimmings and other yard trimmings. In 1989, most of the material collected was grass clippings.

In the past, the material has been stockpiled at the landfill from April to November. Then in November, the materials are shredded and put into windrows. The windrows are turned twice during the composting process with front-end loaders.

In 1987, all of the compost product was used by the City's Parks Department. Currently, the finished compost is taken to a central park in bulk form, where residents can pick up the product free of charge. The material is used primarily as a mulch and soil amendment **(6)** .

Industrial

The Industrial region consists of eight States and, except for the South, has the largest population of the regions defined for the study -- 52,000,000. The eight States are: Delaware, Indiana, Maryland, Michigan, New Jersey, Ohio, Pennsylvania, and West Virginia.

The MSW management policy for the State of Michigan establishes a range of 8 to 12 percent as a goal for diverting yard trimmings from disposal by composting. In early 1989, approximately one percent of Michigan's MSW was being composted in about 100 leaf and/or yard trimmings composting programs throughout the State (7).

The State of New Jersey has the largest number of leaf composting facilities in operation. As of March 1988, there were 175 operational leaf composting facilities in the State (8). The primary end uses for leaf compost are: residential gardening, topsoil companies, nurseries, and public works and parks departments. Other uses include land reclamation and landfill cover. Most municipalities in New Jersey are giving the compost away to residents and charging a nominal fee to bulk users (9) .

<u>Wilmington. Delaware</u>. The Delaware Reclamation Plant in Wilmington is owned by the Delaware Solid Waste Authority and has been operational since 1984. The facility is designed to process about 1,000 tons of mixed MSW per day. Processing includes size reduction, air classification, magnetic separation, and screening to recover metals and glass and to produce a refuse-derived fuel. In addition, the process also generates about 225 tons of residue (primarily paper and plastic). The residue is mixed with an equal amount of biosolids (about 20 percent total solids) and then introduced into one of four reactors for composting. The material is held in the reactor for five to seven days during which time it

is mixed and aerated. The humus from the reactors is dried to approximately a 15 percent moisture content and then screened to remove plastic, glass, and metallic particles. The screened product is pelletized for marketing.

Early analysis of the compost produced by the facility indicated that the material contained PCBS in the range of 4 to 5 parts per million. These concentrations ruled out the original plan to market the product as poultry litter. Present markets being developed include horticulture, lawn fertilizer, and hydroseeding operations.

The product was brought to market in 1989 under the name "Fairgrow." The facility has received a permit from the Department of Natural Resources and Environmental Control to sell the compost to landscapers, nurserymen, and groundskeepers at large corporations, cemeteries, golf courses, schools, etc. The product is not permitted for sale to the general public in Delaware and cannot be used on vegetable gardens because of regulations on heavy metal content in the compost.

The selling price for the compost in 1989 was $4.50 per cubic yard; delivery cost is provided at an additional cost. To encourage first-time users, the operator, Fairfield Service Company, offers the first truckload (up to 20 cubic yards) free of charge. Printed materials are provided to users which include a description of the product, its properties, uses, application rates, and restrictions (10)-(15).

Montgomery County, Maryland. Montgomery County received 18,200 tons of leaves for composting in windrows in 1989. A windrow turning machine is used to turn the piles. The compost is screened and is tested for weed seeds and heavy metals. The finished compost is sold mainly to landscapers and nurseries for $7.50 per cubic yard, in minimum loads of 10 cubic yards. Peak market demand for the compost occurs in the spring. The fall season is the second highest demand period. Compost not sold in the spring may need to be stored at the composting facility for up to six months to be sold through the fall.

In summer 1989, the County undertook a pilot program to add grass clippings to its leaf composting program. With the inclusion of grass clippings, the County will monitor the finished compost for pesticide content (16).

Traverse City, Michigan. After an ordinance was passed in 1986 which banned the burning of combustibles within City limits, a leaf composting program was started in 1987. Loose leaves are collected and formed into windrows. Traverse City plans to incorporate grass clippings and possibly fruit processing by-products into its composting program. The City plans to sell the compost to the public in bulk form (by the cubic yard, the bushel, or pickup truck load) (7) (17).

Essex County, New Jersey. In 1987, Essex County, New Jersey set up a leaf composting program to process the leaves generated by approximately 12 towns in the County. In addition to the central site, 9 or 10 municipal sites are also operated in the area.

Incoming loads are monitored at a gate, and only clean loads are accepted. Plastic bags are not allowed, although paper bags are. During the 1988-89 season, approximately 60,000 cubic yards of leaves were brought in, and 15,000 cubic yards of compost were produced.

The County composts the leaves in windrows. During the first year of operation, the piles were turned with a front-end loader. A windrow turner was purchased during the second year. The leaves undergo 12 to 16 months of processing, and are turned three to five times during this period. No screening or other post-processing is done.

Prior to beginning the program, the County and towns agreed that each town would be responsible for taking their "share" of the finished compost. The share was estimated to be approximately one-third of the volume of leaves dropped off at the site. This ratio was later changed to one-fourth because a larger reduction in volume was experienced than originally anticipated.

The towns are provided with a list of approximately 15 markets that would take the compost for free (or at a nominal cost of $1 per ton) if delivered. Most of the markets on the list are farmers. The list also includes an urban gardening program h Newark and use by the landfill for revegetation and landscaping (not cover). A large share of the compost is used by the towns themselves. According to the County, the problem is not in finding a market for the material; the problem is in getting each town to transport its share to the available market.

No laboratory analyses have been conducted on the product. No restrictions are placed by the County on the use of the product because they feel the compost belongs to each of the towns, rather than to the County. According to a County representative, if a higher quality compost was produced, it could be more attractive to residents and would be easier to market (18) (19).

Franklin Township, New Jersey. Middlebush Compost, Inc. has been composting leaves in Franklin Township since early 1987. Because of restrictions imposed by the State Department of Environmental Protection, the facility is only allowed to accept leaves as feedstock for the composting operation. To maintain a quality end-product and keep processing costs down, the facility does not accept leaves in plastic bags. The finished compost is passed through a three-eighth to half-inch screen.

The leaf compost is subjected to a range of laboratory analyses including pH, organic matter content, and a range of nutrients (see Table A-3). These results are published and made available to prospective buyers. Middlebush Compost has also developed instructions for the application of the product and makes this information available to buyers as well. Recommended application rates and instructions vary depending on the intended use of the product.

Middlebush Compost, Inc. was selling compost at $10 per cubic yard screened and $6 per cubic yard unscreened in 1989. About 20 percent of the compost was used by a landscaper who combined it with soil to make topsoil. The remaining 80 percent was sold to other landscapers, developers, nurseries, garden centers, and homeowners for use as a potting soil, a soil amendment, or as mulch for water retention and weed control, and was also used to cap landfills. In order to establish markets, at first the company gave the product away and conducted a full marketing campaign. By the end of 1989, they were able to sell all of their product. In order to fully meet market demand, the company would like to increase production (20)-(22).

Parlin, New Jersey. Alternate Disposal Systems, Inc. (ADSI) shreds tree stumps and other woody materials from over 100 communities. Following its shredding process, ADSI Sells fine mulch for $12 per cubic yard, coarse mulch for $10 per cubic yard, and topsoil (attached to the stumps) for $10 per cubic yard, primarily to landscapers. ADSI also sells fill material (from crushed rock) (23) .

Wrightstown, New Jersey. Woodhue, Ltd., operates a privately-run facility in Wrightstown, New Jersey to compost various mixes of leaves, brush, tree trimmings, food processing by-products, and livestock manures. Unwanted substances are hand-picked from the incoming material. The feedstocks are placed in windrows where temperature is monitored to determine the turning frequency.

Laboratory analyses are conducted at the beginning, middle, and end of the composting process. On-going analyses include testing for pH, heavy metals, and nutrient content. Other analyses, such as for herbicides and pesticides, are conducted periodically.

The compost is passed through a trommel screen to improve the quality of the product. The finished compost was being sold for $12 per cubic yard in bulk, excluding cost of delivery in 1989. Markets were agriculture, residential home gardening, and commercial users (nurseries, landscapers, etc.) . The New Jersey Department of Transportation has recently accepted the compost

Table A-3

TEST RESULTS - MIDDLEBUSH COMPOST, INC., FRANKLIN TOWNSHIP, NEW JERSEY

Soil Properties	Leaf Compost Mixed with Sand	Leaf Compost
Color	Dark gray brown	Black
pH	7.3	7.8
Organic matter (percent)	18.0	51.0
Specific conductance (CEC), micromhos/cm	300	730
Texture 1/ (USDA Classification)	Sandy loam	Organic soil
-- % Sand (2.0-0.05 mm)	76	
-- % Silt (0.05-0.002 mm)	20	
-- % Clay (<0.002 mm)	4	
Available nutrients: (lb per acre)		
-- Nitrogen (NO_3 and NH_4)	51 (medium)	60 (medium)
-- Phosphorus	33 (medium)	36 (medium)
-- Potassium	205 (high)	150 (medium)
-- NO_3	15.7	26.8
-- NH_4	35.3	33.2
-- Ca	2,255	2,290
-- Mg	42	19
-- Zn	29	20
-- Fe	107	59
-- Mn	19	33
-- B	7	16
-- SO_4	19	30
-- Cl	14	39
-- CU	7	3
-- Total carbon	10.1	28.3
-- Total nitrogen	0.75	1.66
-- C/N ratio	13.5/1	17/1

1/ The texture was tested by the hydrometer method. The soil separates (particles) listed here reflect the size distribution of the inorganic as well as the organic fractions.

Source: Middlebush Compost, Inc.

product as a soil additive. Use by counties and municipalities in the area is being explored (24)(25).

Cleveland, Ohio. The Greater Cleveland Ecological Association serves 16 communities, operates six composting sites, and composts approximately 250,000 cubic yards of leaves in windrows each year. Laboratory analyses have been conducted on cation exchange capacity, pH, heavy metals (lead and cadmium) , and nutrient content (nitrogen, phosphorus, and potassium) by the Ohio State University.

The Association sells compost in four ways:

1. Bag and bushel--people bring their own containers; cost is $0.75 per bushel.

2. Bulk load pickup--customers' trucks are loaded for $13.50 per cubic yard.

3. Home delivery--2 cubic yard minimum, 10 cubic yard maximum, sold at $55.10 for 2 cubic yards and $178.30 for 10 cubic yards including delivery and taxes. For out-of-County delivery, there is an added $20 charge.

4. Bagged in plastic one-cubic yard bags. These are sold through distributors who deal with the nursery and landscaping industries.

A discount is given for semi-truckloads delivered to landscapers and commercial growers to encourage the use of compost on lawns and in potting media for nursery stock. All of the compost has sold out every year.

The Association has plans to begin a pilot program to compost mixtures of wood chips and grass clippings. Prior to implementation of the program, they will subject the grass clippings to laboratory analysis for pesticides. The finished compost will also be tested to determine how the chemicals are broken down during the composting process (26)(27).

Toledo, Ohio. In 1987, the City disposed of 40 percent of its leaves, used 10 percent unprocessed, and gave away 50 percent unprocessed. In order to conserve landfill space, a full-scale effort to obtain users for all of the unprocessed leaves was launched. As a result, in 1988, 100 percent of the 300,000 cubic yards of loose leaves collected were given away. Approximately 90 percent of that amount was delivered to a quarry under an agreement with the City to take at least two-thirds of the leaves collected during the three-year period, 1988 to 1990. The quarry has purchased a shredder and is composting the leaves for land application.

The City offers to deliver leaves free of charge to large users near Toledo. In addition to the quarry, users include a large greenhouse operation that composts the leaves and uses them as a soil amendment. A large canning operation located in Toledo has also agreed to accept leaves for agricultural use (28)(29).

Allegheny County. Pennsylvania. Mount Lebanon, in Allegheny County, has been composting leaves for 17 years. The leaf composting operation averages over 10,000 cubic yards per year. Compost produced is used in parks and on the City's golf course, and is sold to residents for approximately $.50 per bushel.

Allegheny County is planning to set up a series of composting areas in City parks. Finished compost would be made available to municipalities and Parks Departments. Municipalities could use the compost or sell it to residents (30)-(32).

Midlands

Illinois, Iowa, Minnesota, Missouri, and Wisconsin are the States comprising the Midlands region. The five States have a combined population of approximately 29,000,000.

In the State of Illinois, composting is one of the alternative methods for dealing with MSW that is being encouraged. A report issued by the Illinois Department of Energy and Natural Resources states that an estimated 70 percent of the State's MSW stream is compostable. The following components are included: yard trimmings, other municipal organics, biosolids, livestock manures, and agricultural residues (33) .

Chicago, Illinois. During 1987, Chicago experimented with approaches to composting yard trimmings by windrowing various combinations of grass clippings, leaves, and brush. In the fall of 1988, 700 tons of leaves were collected and composted in windrows. During 1989, the City expanded its pilot testing to include: grass collection tests, paper bag collection and processing, and "biodegradable" plastic bag collection and processing. The feedstocks to the test programs have been brush chips, grass Clippings from early spring 1989, and leaves from Fall 1988.

Laboratory analyses of the compost from the test programs have been conducted by the University of Illinois. Tests include heavy metals, herbicides, pesticides, and nutrients. In addition to these analyses, growth tests will be undertaken by the University.

On July 1, 1990, State regulations went into effect that ban yard trimmings from landfills and require source separation of these materials by homeowners. The City planned to implement a full-scale program to compost grass clippings and tree trimmings by that time (34)-(36).

Urbana and Champaign, Illinois. An Intergovernmental Solid Waste Disposal Association has been formed by the neighboring cities of Urbana and Champaign, and by Champaign County. The Association agreement requires that the three member agencies fund and operate a yard trimmings recovery facility that was begun in 1986 by the City of Urbana.

In 1987, the facility received and processed 5,200 tons of yard trimmings from residents and landscapers from the two cities and the County. The facility processes incoming brush into wood chips, heavy wood into firewood, and leaves and grass clippings into compost. The incoming brush is shredded by a tub grinder. The resulting wood chips are sold retail to individual customers or wholesale to landscapers, nurseries, and greenhouses. Large pieces of wood (more than 6 inches in diameter) are split into firewood and sold to the public.

The leaves and grass clippings are placed in windrows and composted for use as mulch. The City of Champaign also collects bagged leaves during the fall and Christmas trees for inclusion in the composting operation. The compost is available free of charge to the public, cities, and parks. It is sold to wholesalers, landscapers, and nurseries. During the fall of 1988, the City of Urbana introduced a curbside yard trimmings collection program using cornstarch plastic bags (37) (38).

Will and Lake Counties, Illinois. Land and Lakes Company is currently operating three leaf composting sites using the results of a Rutgers University leaf composting research project as a basis for its operations. About 300 cubic yards of leaves are processed each week in windrows. The windrows are turned often, and moisture is added to accelerate the composting process.

The finished compost product is named "Compsoil." It is available free of charge to residents, and is also used as landfill cover. The County plans to implement a program in which compost will be available free to residents who drop off yard trimmings at the landfill, at a ratio of 4-to-1 by volume.

Some preliminary laboratory analyses have been completed on the leaf compost. Included in the tests were pH and nutrient content. To further market the product, the County feels the chemical content of curbside collected yard trimmings needs to be analyzed (30)(39).

Afton, Minnesota. Composting Concepts in Afton, Minnesota currently operates a 20-acre site to compost leaves and grass clippings for residents of Woodbury, North St. Paul, and various small communities.

A program using "biodegradable" corn-starch plastic bags that are clear in color was begun in April 1989. Since the bags are clear, unwanted substances can be seen before yard trimmings are added to the composting operation. Consequently, they experience very little contamination in the process itself (except for remaining plastic bag shreds which are screened out) .

The test phase for the cornstarch bags is being run in cooperation with various public agencies including the University of Minnesota, Minnesota Department of Agriculture, and Minnesota Pollution Control Board. No laboratory results on the finished compost were available at the time of this study. No compost could be moved off-site until May 1990. Local nurseries and growers have expressed interest in buying the bulk product (40).

Carver County, Minnesota. A number of yard trimmings composting sites are operating in Carver County. In rural locations, the yard trimmings are dropped off at community composting sites. These materials are collected at curbside in the more urban areas of the County and composted at a centralized facility. The sites accept only leaves, grass clippings, and garden residues. No brush, woody tree parts, or other organic materials are permitted as a normal practice.

At the rural drop-off sites, the yard trimmings are composted in windrows. The compost is generally given back to the area's residents.

The central composting facility is located at the University of Minnesota’s landscape arboretum. The 10,000 cubic yards per year of yard trimmings received at the site are processed using a relatively low-technology windrow composting method. Water is added occasionally and the windrows are turned on the average of two to three times during the composting process. Composting time ranges from 12-18 months. The product is screened before distribution.

In return for the use of the site, the University receives about one-half of the finished compost product for use at the arboretum. During 1989, approximately 500 cubic yards of compost were sold by the County to one landscaper and two-golf courses in the area. The selling price was $12 per cubic yard, including delivery.

Carver County has conducted laboratory analyses of nutrient content, pH, heavy metals, and C/N ratio. The University of Minnesota has also conducted plant growth studies. Weed seeds initially were a problem, but it has been alleviated by altering the composting procedure. After composting is completed, the top six inches of the windrows are removed and composted again.

Beginning January 1, *1990,* yard trimmings (leaves, grass clippings, prunings, and garden trimmings) were banned from landfill disposal in the seven-County metropolitan area of

Minneapolis-St. Paul. Experiments are currently being conducted with larger quantities of grass clippings in the composting medium in order to allow for the increased amounts of grass clippings that will be collected as a result of the ban. The County is also experimenting with other materials including shredded newspaper in the compost feedstock (41)(42).

Fillmore County, Minnesota. The Fillmore County Resource Recovery Center in Preston, Minnesota was built in 1987 and is composting the municipal organics. Because there are separate programs in the area already composting their yard trimmings, these materials are not typically received at the Fillmore MSW composting facility. Recyclable and oversized material are removed prior to composting. Approximately 15 tons per day are composted in windrows. After composting, approximately 40 to 50 percent of the material is screened out as rejects. Various laboratory tests have been conducted by the University of Minnesota on the finished product.

The primary purpose for implementing the MSW composting program was to reduce the County's reliance on landfilling. Therefore, the operators do not have a plan to sell the product at this time. Most likely it will be available free of charge to users who are willing to pick it up. Orchards and agriculture are markets that have expressed an interest in using the product. The operators of the facility are recommending that the compost be used in conjunction with commercial fertilizers and be applied at a rate of about 20-25 tons per acre.

Due to the very wet weather during the 1988-89 winter, the compost was not ready to distribute for spring planting in 1989 as planned (10) (43) (44) .

Hennepin County, Minnesota. In Hennepin County, Minnesota, yard trimmings from residents and landscapers are formed into windrows up to 12 feet in height. A mechanical turner is used to aerate and grind the material.

During the period April through November 1989, 146,000 cubic yards of yard trimmings were collected. Of this, approximately 52,000 cubic yards were processed into compost at the County's site. After screening through a quarter-inch screen, the compost is either used by the County's Parks Department or redistributed to municipalities. The municipalities then make the compost available to residents free of charge, picked up in bulk form.

The remaining 94,000 cubic yards of yard trimmings were distributed as follows: 66,000 cubic yards to private companies interested in producing compost; 18,000 cubic yards to County parks for landscaping; and 10,000 cubic yards to a local farm for landspreading. Laboratory tests are conducted annually for heavy metals (lead, cadmium, mercury), pesticides, and nutrient content (45).

Swift County, Minnesota. A 20 ton-per-day MSW composting/recycling facility is currently under construction in Swift County, Minnesota. When the facility began operation in May 1990, source separated MSW was tipped at the facility in the form of either recyclable, compostables, or nonprocessibles.

Initially, compost use will be limited to landfill final cover and selected County projects until environmental and plant growth studies are completed (46).

Monroe, Wisconsin. In Monroe, Wisconsin, grass clippings are composted with leaves. According to the City, the two materials composted together produce a higher quality compost than either composted separately.

Between 6,000 and 12,000 pounds per day of grass clippings are collected during the summer months. They are piled on land the City owns adjacent to the airport runway and later mixed with leaves for composting. No laboratory tests are conducted.

Truckloads of the finished compost are delivered to users free of charge. The compost is used by the Parks Department, and is distributed to landscapers, a golf course, and farmers. According to the City, the current demand for the product "far exceeds the supply."

The City is currently experimenting with composting the yard trimmings with dewatered biosolids from the local wastewater treatment plant. The compost would be added to fields as a soil amendment (47)(48).

Portage, Wisconsin. A mixed MSW/biosolids co-composting facility has been in operation in Portage since September 1986. The facility processes 30 tons per day of mixed MSW in an in-vessel operation. After composting, the product undergoes fine screening, resulting in 15 to 20 percent of the material being rejected.

The primary purpose for composting the mixed MSW and biosolids is to conserve landfill space. No commercial markets are currently being pursued. The compost is used as landfill cover. Previous testing has shown the product suitable for this use.

The Wisconsin Department of Natural Resources has required the facility to conduct field studies for landspreading. In compliance with these requirements, the compost currently is being spread on test plots at several concentrations. During 1990, crops will be grown and tests will be conducted on metal uptake and leachate (10)(49)(50).

Northeast

The Northeast region has a population of approximately 31,000,000 and is comprised of the following seven States: Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont.

In Massachusetts, approximately 200,000 tons of leaves were estimated to be composted from the autumn 1988 season. Still another 700,000 tons of leaves reportedly were disposed at landfills and waste-to-energy plants (28).

Wellesley, Massachusetts. The City of Wellesley, in cooperation with the City of Newton, operates two yard trimmings composting facilities. One of the facilities accepts yard trimmings from landscapers. Approximately 3,000 cubic yards per year of compost are produced at this site. The compost is used by the highway division for landscaping.

The second composting facility is at the City's Recycling and Disposal Facility. At this site, the general public may drop off yard trimmings at no charge. The 4,500 cubic yards per year of compost produced at this site are marketed as a soil amendment. The City is currently pursuing various methods of advertising the compost. Advertisements are being placed in local newspapers in the early fall and spring. In addition, the City is planning to broadcast advertisements on cable television.

Laboratory testing currently is being conducted by the University of Massachusetts. The analyses will determine the presence of heavy metals, NPK, trace elements, and the organic content of the compost. A pH of approximately 7 has been reported (51).

Fort Fairfield, Maine. A project was begun by the Maine Department of Agriculture to demonstrate the composting of potato processing by-products and cull potatoes. Local farmers and industry Provided equipment and feedstocks. The compost feedstock is comprised of the cull potatoes and by-products, wood ash, paper mill biosolids, and sawdust.

During the demonstration program in 1989, 484 tons of compost were produced. According to Al Dixon, Town Manager, the product is a "nice organic product, smells like dirt, and is pretty as peat." The compost is being tested by a local farm on oats, peas, potatoes, and broccoli crops at various application rates. The same crops are being grown on fields without compost. Tests will be conducted on the compost product, soil samples, and the crops over a period of three years.

The town plans to expand the program to produce over 2,000 tons of compost in 1990. Future plans are to market the compost in bulk to the farming community (52)(53).

Thomaston, Maine. The State Department of Environmental Protection has permitted a 23-acre site in Thomaston, Maine to compost fish processing by-products. North Atlantic Products has been involved with pilot composting programs since 1987, and began operation in Thomaston in June 1989. The material is mixed with sawdust and mechanically turned. The company expects to produce 500 tons of finished compost by November. The product is undergoing laboratory analysis for NPK and trace elements. The raw materials are being tested for heavy metals. North Atlantic Products is actively seeking more markets for both bagged and bulk sales, and plans to market the product under the name "Sea Green" (54)(55).

Brookhaven and Holtsville, New York. The Department of Highways in Brookhaven composts approximately 200,000 cubic yards of leaves annually, using windrows, at the Holtsville Ecology site and Manorville Transfer Station.

During initial operations, plastic bags had been creating problems in the composting operation, both in clogging processing equipment and reducing the quality of the finished product. In 1987, the Highway Department purchased 400,000 paper bags and offered them free to residents. According to the operator, the pilot program demonstrated that curbside collection of paper bags was more convenient and efficient than with plastic bags, and that the paper bags decomposed as quickly and inexpensively as composting loose leaves.

Laboratory analyses were conducted by Cornell University for heavy metal contamination during the paper bag pilot study. All test results were acceptable according to the standards established by the U.S. EPA for biosolids composting. Currently, only pH is tested for at the Ecology site.

Approximately 50-75 percent of the compost produced is given away to residents for use in gardens and on lawns. Small bags are given to Girl Scout troops and other groups for potted plants. The compost is used by the local garden club and in the community garden. The remainder is used for municipal projects (35)(52)(56).

Islip, New York. In September 1988, Islip expanded its yard trimmings composting program to a full-size operation. The town anticipates processing at least 70,000 tons per year of grass clippings, leaves, and tree trimmings.

Yard trimmings are collected at curbside, and are received at the facility primarily in plastic bags. They are then shredded, trommel screened, windrowed, and turned periodically. The trommel has recently been added to the process and is expected to be able to remove approximately 90 percent of the plastic in the feedstock.

Laboratory analyses conducted on the compost have been very favorable. The finished compost is usually given away. Currently, it is available to residents and local landscapers on a first-come, first-serve basis. The town is in the process of providing 25,000 cubic yards to develop a golf course in the area. At the present time, market demand exceeds the available supply.

The town is exploring potential commercial markets such as turfgrass growers, landscapers, and other users of soil amendment products. It is uncertain at this time as to whether the product will be marketed in bag as well as bulk form (54) (57).

Saratoga Springs, New York. The horse manure and bedding from the Saratoga Springs Raceway are composted and sold as "Saratoga Organic." The Saratoga Springs Raceway houses over 1,000 horses on the premises, which generate 150 to 200 cubic yards per day of manure and bedding material. The composting operation is conducted inside a building over a two-week period. Forced aeration, controlled via computer, is used to maintain proper oxygen levels. The flow of oxygen is controlled by computer, based on data from temperature probes inserted in the piles. Laboratory analyses have been conducted by Cornell University. The finished compost is shredded, but not screened. It is bagged and sold to both retail and wholesale markets (58) (59).

Scarsdale, New York. Yard trimmings have been composted in the City of Scarsdale since the mid-1960s. Currently, the City works with a local nursery to compost approximately 35,000 cubic yards per year of yard trimmings and distribute the product. The yard trimmings are delivered throughout the year.

Leaves are composted (aerobically) in windrows. Grass clippings, shrubs, and tree trimmings are composted (anaerobically) in cells for five years.

In return for a share of the finished product, the nursery assists in turning the windrows and provides storage space for the finished compost. The City uses as much of the screened compost as it needs. Twice a year (spring and autumn) the City sponsors giveaway weekends, during which time bulk compost is available free of charge to residents. The remaining compost is marketed by the nursery as mulch and is also blended in potting soil and topsoil. The nursery sells the compost products both in bulk and in bags. Laboratory testing is conducted by the nursery (60)(61).

Pacific

The Pacific region has the fewest States of any of the regions defined for the study. It consists of California, Oregon, and Washington, with a combined population of approximately 35,000,000.

Davis. California. The Davis Waste Removal Company has been composting yard trimmings generated in the City of Davis since December 1981. During the first five years of operation, approximately 10,500 tons (225,000 cubic yards) of loose brush and leaves were collected and processed. Approximately 4,875 tons (15,600 cubic yards) of compost were produced. Of this, 1,175 tons were sold and the remaining 3,700 tons were given to residents of Davis. Of the compost that was sold, the primary market was local landscapers.

The yard trimmings are collected at curbside using a "claw." Unwanted substances are removed, and the material is shredded, formed into windrows, and turned every two weeks.

The company has had laboratory analyses conducted on the compost. The results during the first five years showed that they were unable to produce a consistent product. The average composition analysis of the compost during those years was **as** follows:

Moisture (%)	60
Total solids (%)	40
Volatile solids (%)	34
Carton/nitrogen ratio	45:1
Carbon (%)	22
Nitrogen (%)	0.48
Phosphorus (%)	0.16
Potassium (%)	0.24

The finished compost product currently is available in bulk form at no cost to residents. According to a representative from the company, problems with the quality of the finished compost have been encountered, primarily due to a lack of control of the incoming feed stream and the high C/N ratio. Because of these problems, the facility now composts primarily leaves (62)(63).

Palo Alto. California. The City of Palo Alto's yard trimmings composting program began full scale in 1979. In 1988, 22,000 cubic yards of material were received at the facility, and 8,799 cubic yards of compost were produced. The type of materials accepted are clean plant trimmings. The material is processed through a tub grinder and then formed into windrows. Turning is done with a bulldozer at least once per month.

The product is produced for eventual cover of a 146-acre landfill to convert it into a park. The compost will be mixed with dirt at a ratio of l-to-2. Use of the compost for landfill cover will displace material that would need to be purchased at a cost of approximately $15 per cubic yard (64)-(66).

San Mateo, California. The City of San Mateo began its yard trimmings composting program in April 1982. Yard trimmings composted included garden and tree trimmings. Incoming loads were checked for conformance with a published list of acceptable materials. The site attendants had the authority to reject unsuitable materials such as food scraps, rotten or odorous materials, plastic or paper containers, pet animal manure, diseased or infected materials, and poisons or hazardous wastes.

The materials were then size reduced and formed into windrows. The windrows were then aerated. During the 1986-1987 fiscal year, 41,000 cubic yards of raw materials were processed to produce 27,000 cubic yards of compost. Some laboratory analyses of the product have been conducted, including organic content and nitrogen content. Approximately 150 cubic yards per year of the product were used by the Parks Department as a soil amendment with favorable results. Most of the compost was stockpiled with the intention of using it in the development of a 35-acre landfill site into the Shoreline Park.

As of September 1989, San Mateo was no longer accepting yard trimmings for composting. The site had accumulated a stockpile of compost in excess of its needs for the Shoreline Park, and is selling the excess at $6.50 per cubic yard to customers who will pick it up at the site. Topsoil providers and the general public are the primary customers. Approximately 3,000 cubic yards were to be used by the Parks Department in municipal projects during 1989 (67)-(69).

Portland, Oregon. There are two major producers of yard trimmings compost in the Portland area: Grimm's Fuel Co. and McFarlane's Bark, Inc. In addition, East County Recycling Co. size reduces through shredding yard trimmings into a mulch.

At the Grimm's facility, yard trimmings are size reduced and piled. The shredded product is aerated during the composting period, screened, and the oversized material is shredded again. Grimm's markets the compost alone and also blends it with sandy loam and barkdust.

The yard trimmings received at McFarlane's are stockpiled in preparation for processing. The material is shredded and heaped into piles, and allowed to compost for three to six months. Prior to selling the product, the material is shredded and screened. The compost is blended with sawdust in a 9-to-1 ratio before selling.

Both Grimm’s and McFarlane’s have targeted three major markets: residential customers, landscapers, and nurseries.

Grimm's has been actively trying to produce a material of consistent, reliable quality to be used as a potting medium in the nursery industry. The shredded yard trimmings produced by East County Recycling are given free of charge to residents (70)-(72).

Kina County, Washington. Pacific Topsoils, near Seattle, composts grass clippings, leaves, and prunings from various parts of King County. Incoming yard trimmings are visually inspected for plastics, rocks, etc., shredded to accelerate the composting process, and formed into windrows. Some of the compost is screened and sold as a decorative ground cover to be used in place of bark. It is marketed under the name "Pacific Garden Mulch." Pacific Topsoils also blends the compost with the company's other soil amendment products and in its topsoil. The company concentrates on the commercial landscaping market, although other markets are targeted as well.

Laboratory analyses for organic content, soil fertility, and macronutrients and micronutrients are conducted quarterly. The company recommends that the compost be applied to the soil in a three- to six-inch layer (22)(73)-(75).

Seattle, Washington. A Seattle city ordinance states that yard trimmings must be source separated. The City's composting programs are designed to handle 75 percent of the yard trimmings typically disposed of. In 1989, Seattle implemented a three-pronged approach to diverting yard trimmings: 1) backyard composting; 2) curbside collection City-wide; and 3) self-haul for a discounted tipping fee.

The City is encouraging backyard composting of yard trimmings by giving composting bins to homeowners. In its first year, starting in September 1989, the program planned to distribute 6,000 composting bins to Seattle residents. The bin is delivered by a composting instructor who provides the resident with a one-hour home consultation explaining how to use the bin, helping the resident set the bin up for use, assessing their yard trimmings generated.

Another facet of Seattle's backyard composting program is the Master Composter Program, which was begun in 1985. Since then, 75 master composers have received training and four backyard composting demonstration sites have been developed around the City. The program is projected to reach 70,000 households over a span of seven years.

Seattle's curbside collection program for yard trimmings was implemented City-wide in January 1989. Yard trimmings are transported to a centralized composting site. As of September 1989, no saleable product had been produced at that composting site. The anticipated current market value for the compost end product was $2.00 per cubic yard.

The self-haul program began operation in January 1989, and is available at both of Seattle's transfer stations. During the first seven months of 1989, residents and businesses dropped off almost 7,000 tons of yard trimmings at the sites (35)(76)-(79).

South

The South is the largest region in this study in terms of population. The eleven States in the region, which have a combined population of approximately 56,000,000 are: Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia.

Gentry, Arkansas. In Gentry, manure from broiler chickens is composted in windrows. The finished product is marketed to sod farmers, landscapers, and golf courses (80).

Ft. Lauderdale, Florida. The City of Ft. Lauderdale, in Broward County, operates a composting plant to process biosolids, using trimmings from commercial tree surgeons and wood chips as bulking agents. The facility is designed to process 35 tons per day (250 cubic yards per day) of biosolids cake in reactors and accepts 1,000 to 1,500 cubic yards per week of yard trimmings.

Small amounts of the compost have been used by nurseries and the general public. The Soil and Water Conservation District is currently considering use of the product. Local environmental restrictions have made landspreading very difficult (81) (82).

Perry, Florida. America's largest blue crab scrap composting project receives most of the crab processing residues generated in the Florida panhandle. The crab scrap deliveries, averaging 13 tons per day, are mixed with sawdust, pine bark, shredded leaves, brush, other yard trimmings, and other locally available carbonaceous materials. The material is placed in windrows outdoors and turned frequently over a two-month period, followed by curing for two months.

The crab compost is screened and then marketed under the "Suwanee River Natural Organics" label for $25 per cubic yard bulk, or $3 per 40-pound bag wholesale to local nonprofit groups (e.g., 4-H, garden clubs) for use as a fund raiser. The compost is also sold as high-quality potting soil which is sold at retail for $6 per 40-pound bag.

The University of Florida is conducting field trials and growth studies, and the seven local Soil and Water Conservation Districts are helping to introduce the compost to local farmers (83).

Sumter County, Florida. A windrow composting facility to process mixed MSW has been on-line since mid-1988 in the County.

The facility is operated by U.S. Waste Recovery. Information from the County and the operators indicates that 50-70 tons of residential and commercial discards are received each day.

The composting process is begun by passing the material through a flail mill designed to break open bags and packages, thus allowing their contents to mix with the remainder of the MSW stream. The incoming material is then subjected to magnetic separation to remove ferrous metals. Aluminum and other inert matter are removed manually. The remainder of the material is size-reduced to an approximate two by two-inch particle size.

The shredded product is transferred to a composting pad where it is stacked in windrows, and a bacterial implant is added. The finished product is being tested for organic matter, pathogens, and heavy metals.

As of October 1989, no compost had been marketed. Plans are to sell the material to nurseries as an alternative to peat, to soil amendment dealers, and to contractors for landscaping near roadways. Market development efforts were being delayed until State guidelines for compost are finalized by the Florida Department of Environmental Regulation (84)(85).

Mecklenburq County, North Carolina. The County is currently conducting a yard trimmings recycling program in which woody material is shredded into mulch. Approximately 200-300 tons per day of the materials are received at the facility. The mulch is used by the Board of Education, Public Works Department, and the Parks and Recreation Department. Additionally, over one-half of the mulch is sold to the public at $6 per cubic yard, picked up at the site.

In 1990, the County plans to implement a full-scale yard trimmings composting program at two sites. Approximately 375,000 cubic yards per year of yard trimmings will be processed. In addition to continuing to shred woody materials into mulch, leaves and grass clippings will be composted in windrows.

Mecklenburg County is currently exploring markets for the compost. The County hopes to market the product in bulk to large end-users such as nurseries and greenhouses (86) (87).

SUMMARY

The results of the assessment of existing composting programs and markets show that there is a considerable interest in composting in the United States. The interest seems to be driven largely by economic and regulatory factors, as well as for environmental reasons. The markets for the finished product vary from uses by public entities, to wholesale and retail sale, to residents and commercial markets.

A summary of the characteristics of this study is presented in Table A-4. The data in the table show that there seems to be a rough correlation between the tipping fee for landfill disposal and the number of operational composting programs. The highest average tipping fee was $58 per ton in the Northeast region. This region had one of the highest number of composting projects. On the other hand, the lowest average tipping fees were $9 and $14 per ton in the Central and South regions, respectively. As of April 1989, the Central region had only seven yard trimmings or MSW composting projects, and the South had six.

Another factor that plays a critical role in the number of composting programs is regulating materials to be disposed of. Several States in the Industrial, Midlands, and Northeast regions have passed legislation to ban the disposal of yard trimmings in landfills. A discussion of the regulatory factor was presented in the section entitled Policies in Chapter 4.

Table A-4

CHARACTERISTICS OF THE SIX STUDY REGIONS
(July 1989)

	Central	Industrial	Midlands	Northeast	Pacific	South
Number of States	14	8	5	7	3	11
Population in 1987 (millions)	39	52	29	31	35	56
Population density (population/square mile)	26	235	91	278	110	110
Average landfill tipping fee ($/ton) 1/	9	28	20	58	29	14
Number of yard trimmings composting programs	7	354	135	134	15	5
Number of operational MSW composting programs	0	1	4	0	1	1
List of States	AZ CO ID KS MT NE NV NM ND OK SD TX UT WY	DE IN MD MI NJ OH PA WV	IL IA MN MO WI	CT ME MA NH NY RI VT	CA OR WA	AL AR FL GA KY LA MS NC SC TN VA

(continued)

Table A-4 (cont.)

1/ Average of tipping fees reported in Pettit, C.L. "Tip Fees Up More Than 30% in Annual NSWMA Survey." Waste Age, 20(3):34-39. March 1989.

Sources: Glenn, J. and D. Riggle. "Where Does the Waste Go? -- Part I." BioCycle. 30(4):34-39. April 1989.

Goldstein, N. "Solid Waste Composting in the U.S." BioCycle, 30(11):32-37. November 1989.

Appendix A

REFERENCES

1. Glenn, J. "The State of Garbage in America: Part 1." BioCycle, 31(3):48-53. March 1990.

2. Goldstein, N. "Solid Waste Composting in the U.S.." BioCYcle, 30(11):32-37. November 1989.

3. Solid Waste Management in the Denver Region. Prepared by the Solid Waste Task Force. 1986.

4. Personal communication with Trish Kenney, City of Boulder. 1989.

5. Personal communication with Gene Hanlon, City of Lincoln. 1989.

6. Personal communication with Dan Slattery (1987 and 1989) and Marty Crater (1989).

7. Goldstein, J. "1O Percent 'Off the Top' for Composting." BioCYcle, 30(2):26-27. February 1989.

8. "Operating Leaf Compost Facilities in New Jersey." Prepared by the New Jersey Department of Environmental Protection. March 22, 1988.

9. "Options for Municipal Leaf Composting." BioCycle, 29(9) :38-43. October 1988.

10. Diaz, L.F. and C.G. Golueke. "Compost Experience in the USA." Presented at the International Symposium on Compost Production and Use. Italy. June 1989.

11. "The Delaware Reclamation Plant." Delaware Solid Waste Authority. 1988.

12. "Fairgrow Easy Reference Chart." Fairfield Service Company. 1989.

13. "Giving Nature a Hand." NCC Business. October 1989.

14. Personal communication with John Neyman, Delaware Solid Waste Authority. 1989.

15. Personal communication with Rebecca Roe, Fairfield Service Company. 1989.

16. Personal communication with Doreen Cantor, Montgomery County. 1990.

17. Personal communication with representatives from Traverse City. 1989.

18. "N. J. County Seeks Ways to Get Rid of Compost." Recycling Times. May9, 1989.

19. Personal communication with Paul Petto, Essex County, New Jersey. 1989.

20. Meade, K. "Waiting for the Leaves to Fall." Waste Alternatives, pp. 34-38, March 1989.

21. Personal communication with Matthew Vastano, Middlebush Compost, Inc. 1989.

22. Taylor, A.C. and R.M. Kashmanian. Yard Waste Composting: A Study of Eight Programs. Us. Environmental Protection Agency. Office of Policy, Planning and Evaluation; Office of Solid Waste and Emergency Response. EPA/530-SW-89-038. April 1989.

23. Personal communication with Patrick Kennedy, Alternate Disposal Systems, Inc. 1990.

24. Salimando, J. "Woodhue Compost. . .or Wouldn't You?" Waste Age, 20(5):63-64. May 1989.

25. Personal communication with Joe Hayes, Woodhue, Ltd. 1989.

26. Logsdon, G. "A Business-like Approach to Leaf composting." BioCycle, 30(3):22-24. March 1989.

27. Personal communication with Edward Janesz, Greater Cleveland Ecological Association. 1989.

28. "News Breaks. " Waste Age, 20(3):28. March 1989.

29. Personal communication with Steven Hayden, City of Toledo. 1989.

30. " Slants and Trends." Solid Waste Report, 20(14):105. Apr i 1 3, 1989.

31. Personal communication with Don Berman, Allegheny County. 1989.

32. Personal communication with Jim Caine, Mount Lebanon. 1989.

33. Illinois Department of Energy and Natural Resources. Composting Municipal Solid Waste. Undated.

34. "Regional Roundup." BioCycle, 29(3):11. March 1988.

35. O'Brien, J.K. "Prospects for Year-Round Composting of Municipal Yard Waste." Resource Recovery, pp. 26-27. February 1989.

36. Personal communication with Doug Ziesemer, City of Chicago. 1989.

37. Darling, J.S. "Twin Cities Tackle Their Waste Problems Together." World Wastes. Undated.

38. Personal communication with Laura Marshall, Intergovernmental Solid Waste Disposal Association. 1989.

39. Personal communication with Harry Morris and Jim Embroso, Land and Lakes Company. 1989.

40. Personal communication with Richard Eisinger, Composting Concepts. 1989.

41. Personal communication with Michael Lein, Carver County. 1987 and 1989.

42. "Yard Waste Disposal is Banned in Metro Area." Carver County Solid Waste Newsletter. October 1989.

43. Personal communication with Neil Bremseth, Fillmore County Resource Recovery Center. 1989.

44. Fillmore County Resource Recovery Center. Agricultural Use of Solid Waste Compost. 1988.

45. Personal communication with Bill Brenna (1987 and 1989) and Paul Kroening (1989), Hennepin County.

46. Cal Recovery Systems, Inc. Pilot source separation program for Swift County, Minnesota. 1989.

47. "Composting Projects for Grass Clippings" BioCycle, 29(5):47. May/June 1988.

48. Personal communication with Nate Klassy, City of Monroe. 1989.

49. Personal communication with Surgit Saini, Wisconsin Department of Natural Resources. 1989.

50. Personal communication with Tom Pinion, Portage Department of Public Works. 1989.

51. Personal communication with David Pilkington, Department of Public Works. 1989.

52. "Regional Roundup." BioCycle, 30(6):13,15. June 1989.

53. Personal communication with Al Dixon, Town Manager. 1989.

54. "Regional Roundup." BioCycle, 30(4):19. April 1989.

55. Personal communication with Ron Jackson, North Atlantic Products. 1989.

56. Personal communication with Timothea Nalepa, Holtsville Ecology Site. 1989.

57. Personal communication with Dr. Stewart Bruckner, Department of Environmental Control. 1989.

58. Personal communication with personnel from Saratoga Springs Raceway. 1989.

59. Logsdon, G. "Racetracks Bet on Composting." BioCycle, 29(3):38-39. March 1988.

60. Personal communication with Jim Rice, City of Scarsdale. 1989.

61. Rice, J.E. "Leaf Bagging vs. Curb Collection." BioCycle, 29(2):30-31. February 1988.

62. Gertman, R. Davis Waste Removal Company Compost Program. Undated.

63. Personal communication with Paul Geisler (1987) and Ken Sheppard (1989), Davis Waste Removal Company.

64. Personal communication with Russ Reisierer, City of Palo Alto. 1987 and 1989.

65. "Municipal Recycling Programs: Potential for Waste Management and Energy Savings." Energy Task Force of the Urban Consortium for Technology Initiatives. Denver, Colorado. 1985.

66. "City of Palo Alto Composting Program." February 1989.

67. Department of Public Works, City of San Mateo. Compost Material Guide. 1984.

68. Bergeron, A.T. "6,000 Tons Diverted: Recycling Plant Materials." BioCycle, 29(2):29-31. February 1989.

69. Personal communication with Vernon Ficklin, City of San Mateo. 1989.

70. Cal Recovery Systems, Inc. Portland Area Compost Products Market Study. Prepared for the Portland Metropolitan Service District. Portland, Oregon. 1988.

71. Personal communication with Rod Grimm, Grimm's Fuel Co. 1988.

72. Personal communication with representatives from McFarlane's Bark Co. 1988.

73. Johnson, B. "Kirkland Recycling Program Gets Unexpected Success." World Wastes, 32(2): 26-27. 'February 1989.

74. Personal communication with Dave Foreman, Pacific Topsoils. 1987.

75. Personal communication with Dorran McBride, Pacific Topsoils. 1989.

76. Johnson, B. "Public Participation Helps Seattle Set Recycling Goal." World Wastes, 32(2): 20, 22. Undated.

77. Personal communication with Carl Woestendiek, Seattle Solid Waste Utility. 1989.

78. "Seattle's Backyard Composting Program. " Seattle Solid Waste Utility. 1989.

79. "Yard Waste Program Update - August 1989." Seattle Solid Waste Utility. 1989.

80. Personal communication with Les Hileman, University of Arkansas (retired). 1989.

81. Personal communication with John Jackson, Ft. Lauderdale Compost Plant. 1989.

82. "Private Role Grows in Yard Waste Composting." BioCYcle, 28(9):36-38. October 1987.

83. Personal communication with Clark Gregory, Woods End Laboratory. 1990.

84. Personal communication with Mike Olson, U.S. Waste Recovery. 1989.

85. Personal communication with Gary Breeden and Tommy Hearst, Sumter County. 1989.

86. "New Emphasis on Yard Waste." BioCycle, 28(8) :42-46. September 1987.

87. Personal communication with Allen Giles and Brenda Bardner, Mecklenberg County. 1989.

Table A

CHARACTERISTICS OF THE SIX STUDY REGIONS (Fall 1991)

	Central	Industrial	Midlands	Northeast	Pacific	South
Number of States	14	8	5	7	5	11
Population in 1987 (millions)	39	53	29	31	39	57
Number of yard trimmings composting programs	35-45	524	341	432	35	40
Number of operational MSW composting programs	3	1	9	0	2	3
Number of States that ban yard trimmings from landfills	0	5	5	3	0	4
Number of States with recycling laws	3	8	5	7	3	6
List of States	AZ CO ID KS MT NE Nv NM ND OK SD TX UT WY	DE IN MD MI NJ OH PA WV	IL IA MN MO WI	CT ME MA NH NY RI VT	AL CA HI OR WA	AL AR FL GA KY LA MS NC SC TN VA

(continued)

Table A (cont.)

Sources: Goldstein, N. Personal communication. October 1991.

Glenn, J. and D. Riggle. "The State of Garbage in America: Part I" BioCycle. 32(4):34-38. April 1991.

Howson, C. "Recycling Laws Impacting at State Level." Waste Tech News. October 1991.

Kashmanian, R. Personal communication. March 1992.

Table B

OPERATIONAL MSW COMPOSTING/CO-COMPOSTING FACILITIES IN THE U.S. (Fall 1991)

Location	Type of System	Capacity (TPD)
Arizona		
Pinetop-Lakeside	Eweson	12 MSW; 5 biosolids
Delaware		
Wilmington	Fairfield	250-350 processed MSW; 70 biosolids (dry)
Florida		
Escambia County	Windrow	130 MSW; septage
Pembroke Pines	Buhler	660 MSW
Sumter County	Windrow	120 design (50 actual)
Iowa		
Des Moines	Windrow	192 MSW; 115 biosolids (wet); 38 yard trimmings
Kansas		
Coffeyville	Windrow Raw MSW	80 MSW
Minnesota		
East Central Solid Waste Commission	Daneco	250 MSW
Fillmore County	Windrow	18 MSW
Lake of the Woods County	Windrow	10 MSW
Pennington County	Lundell w/ windrows	10 (RDF residuals)
Prairieland	OTVD w/ agitated bed	100 MSW
St. Cloud	Eweson w/ agitated bed	100 MSW
Swift County	Windrow	25 MSW

(continued)

Table B (cont.)

Oregon		
Portland	Dano w/ windrows	600 MSW
Texas		
Hidalgo County	Windrow	150 MSW
Washington		
Ferndale	Eweson w/ agitated bed	300 MSW
Wisconsin		
Portage	Digester w/ windrows	16 MSW; biosolids

Sources: Goldstein, N. and R. Spencer. "Solid Waste Composting in the United States." BioCycle, 31(11): 46, 48-50, November 1990.

Goldstein, N. Personal communication. October 1991.