INTRODUCTION
GOAL AND SCOPE OF THE PROJECT

This report describes a project initiated by the Bureau of Waste Prevention, Reuse and Recycling to determine whether or not municipal solid-waste (MSW) composting merits further, serious investigation by the New York City Department of Sanitation (DSNY, or the Department) in its search for increased recycling rates and decreased dependence on waste export. The simple answer to this question is, yes, further investigation is warranted.

To accomplish this goal, the project had the following objectives:

- Compost samples of municipal solid waste generated in New York City (the City).[1]
- Determine the quality of the compost produced from these samples, as well as the recycling recovery rate achieved by the process.
- Assess the general performance of other, operational MSW-composting facilities in terms of compost quality, odor control, process efficiency, and other factors that might affect potential application of this technology to the City.
- Develop an estimated cost-per-ton with which to compare MSW composting to current export and disposal options.

In order to meet these objectives, the project involved the following four tasks:

- Sending samples of New York City waste (50 tons per day for five days) to a commercial-scale, MSW-composting facility, located in Marlborough, Massachusetts (Marlborough) and conducting Composting Trials.
- Sorting and characterizing representative samples of the New York City waste used in the Composting Trials into fractional components in order to determine an overall process recovery rate.
- Surveying other commercial-scale, MSW-composting facilities operating in North America.
- Conducting extensive laboratory testing of the material throughout the entire MSW-composting process to determine the quality of the resulting compost. This included samples from both the New York City Composting Trials at Marlborough, as well as from the surveyed MSW-composting facilities.
- Developing a scenario for a theoretical pilot facility in New York City, in order to conduct a full-scale financial analysis, and calculate an estimated per-ton processing cost.

MSW Composting: The Basic Concept and a Brief History

The principal behind MSW composting is to direct the entire, mixed-solid-waste stream to a centralized, enclosed, odor-controlled facility, in order to recover (compost) the *degradable* fraction. The *non-degradable* fraction of the waste stream is directed for recycling, or disposal as garbage, after being separated out via manual sort lines and/or mechanized screens and other sorting processes. (It should be noted that MSW composting can, and often does, exist alongside

Photo 1: Aerial view of the Edmonton Facility
The newest and largest MSW-composting facility in North America, located in Alberta, Canada, began operating in 2000.

traditional curbside recycling programs, which require residents to separate out designated recyclable materials from the waste stream before setting materials at the curb for collection.)

The MSW-composting technologies commonly used in the United States were developed in Europe more than 30 years ago. In the past decade, several European countries have shifted their focus from mixed MSW to source-separated organics, or "biowaste" composting, in order to meet stringent quality requirements in agricultural markets. More recently, there has been another upsurge in mixed-waste composting in Europe due to pressure and regulations to address "greenhouse" gas emissions resulting from the landfilling of unprocessed organic waste.

There are currently 13 MSW-composting plants operating in North America (two in Canada and 11 in the U.S.). An additional seven plants are under development in the U.S. The facilities range in capacity from eight tons per day to 825 tons per day of MSW. The oldest running MSW-composting plant in North America is the Dennington County facility in Minnesota, in operation since 1987. The newest (and largest) is the Edmonton facility in Alberta, Canada, which began in 2000.

Despite the appeal of MSW composting (described below), the technology has experienced a rocky start-up over the past 20 years in this country, including some notable failures. A number of U.S. operations have closed primarily due to issues related to product quality and odor control. While other facilities, like the Bedminster plant in Marrietta, GA, have made significant strides (and investments) to improve in these areas. Built in 1995, the Marrietta plant underwent major renovations in 1998, and has operated successfully at capacity for the past five years (300 tpd of mixed waste).

Several plants built in the past three to four years, such as the Bedminster facility on Nantucket Island, MA, have performed as anticipated. While there are no doubt improvements yet to come, the industry appears to have arrived at a point where it can produce a known and consistent compost product, while effectively managing odors through proper air-handling and biofiltration.

The assessment made by *BioCycle Magazine* in its 2000 national survey of mixed-waste composting in the U.S. still applies:

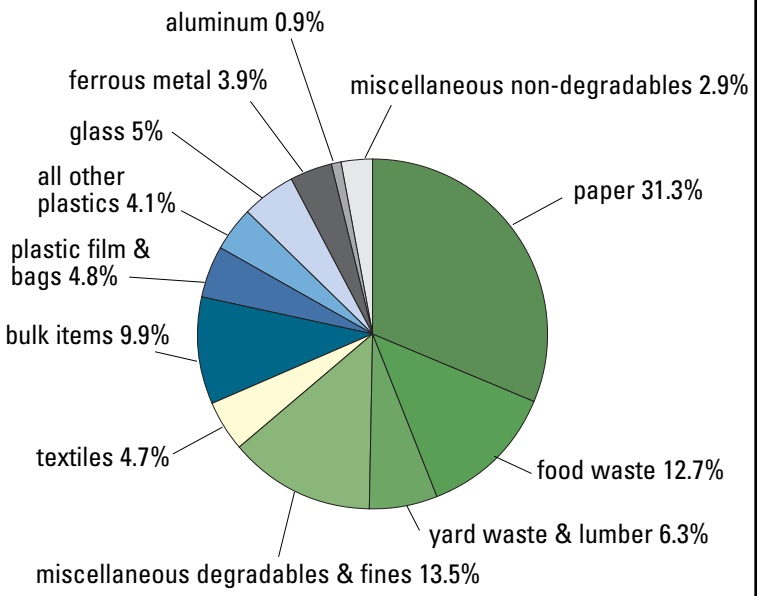
"…those (facilities) with the waste flow, cash flow, good process and odor management, viable end users, a well-defined mission and purpose and political support are doing well."[2]

MSW Composting in the Context of New York City

With the closure of the Fresh Kills Landfill in 2001, New York City has become entirely reliant on facilities outside of its borders to dispose of its solid waste. The Department has entered into short-term contracts for export and disposal that currently cost an average of $70 per ton. Long-term projections indicate that the City's export and disposal costs will average $95 per ton. As never before, the City has incentives to develop alternatives to disposal.

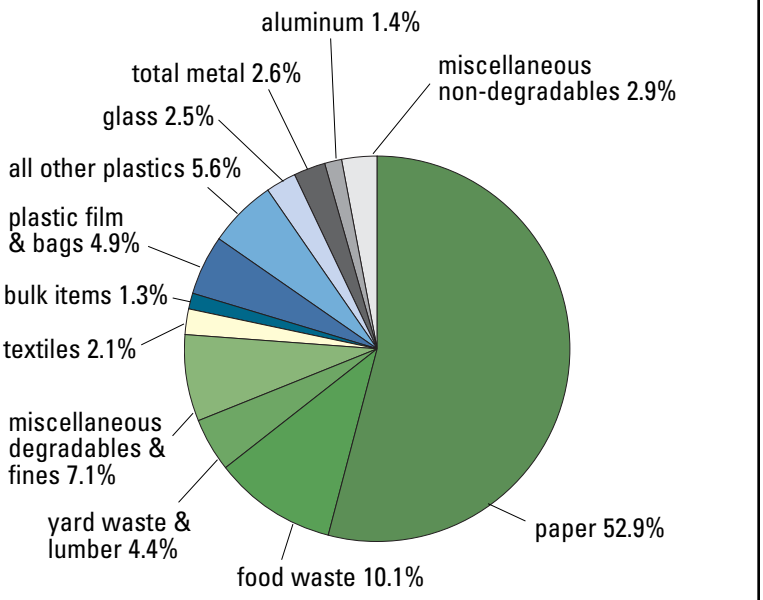
The first logical question to ask when looking for alternatives to disposal is, "What's in the garbage?" In 1990 (before the inception of the citywide, curbside recycling program), the Department conducted a comprehensive, multi-season, waste-composition study to answer that question. Figure 1 presents the average, annual, citywide, residential-waste components as a pie chart, while Figure 2 summarizes the composition of the institutional waste that the Department collects (from public schools, City offices, etc.). From a pragmatic, operational perspective, the division between institutional and residential waste is illusionary, as DSNY collects these two streams together.

Figure 1
Annual, Average, Citywide, Residential-Waste Composition (1990)



Source: 1992 Solid Waste Management Plan, Appendix 1.2, Waste Stream Data

Figure 2
Annual, Average, Citywide, Institutional-Waste Composition (1990)



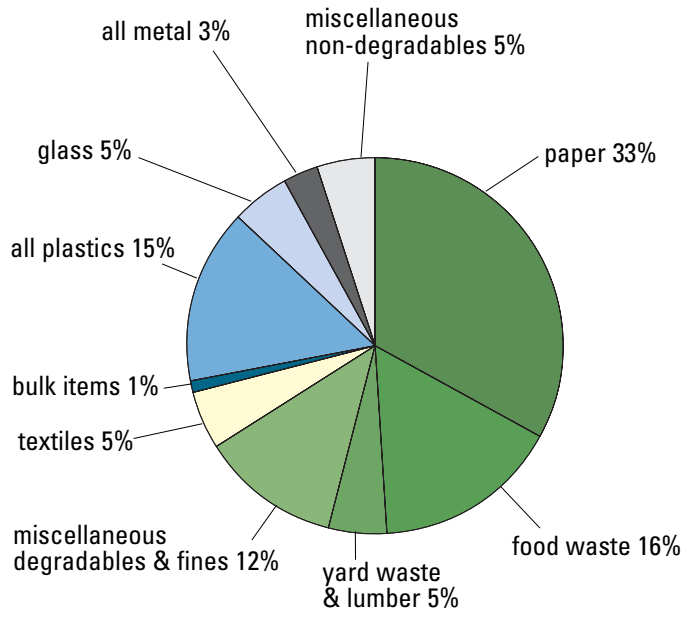
Source: 1992 Solid Waste Management Plan, Appendix 1.2, Waste Stream Data

A useful way of thinking about these materials is to group them as either biodegradable ("degradable") or non-degradable. Everything organic (derived from once-living organisms) eventually degrades over time. What is meant here, rather, is *readily* degradable (or compostable) material that breaks down over a short period of time. For example, plastics and certain textiles, while organic, are not classified as degradable. Therefore, the residential waste stream is 63.8% degradable (shown in shades of green) and 36.2% non-degradable. The institutional waste stream is 74.5% degradable and 35.5% non-degradable.

While paper is readily degradable, recycling paper into new paper products represents a higher end use for this material, and is therefore preferable to composting it. However, even with a curbside, mixed-paper-recycling program, paper products still comprise roughly a third of the post-recycling waste stream. Figure 3 presents the results of a waste characterization that the Department performed in association with this Research Project on samples of "black-bag" waste (or regular garbage). It should be noted that the waste samples for this study were not representative of the City as a whole, nor did they take into account seasonal differences. For more information on the limitations of this data, see Chapter 1.

As readily degradable materials comprise over half of the post-recycling, municipal solid-waste stream, it is understandable that the Department would seek ways to divert these items from disposal, and redirect them for composting. This has been a goal since the inception of the recycling program in 1989. The initial focus was to test the feasibility of asking waste generators serviced by the Department (NYC residents and institutions) to source-separate degradable material for collection.

Figure 3
Post-Recycling Waste Composition (2001)



Note: Results from representative residential- and institutional-waste samples from Staten Island District 2. (See Chapter 1 for more information.)

The Department ran two pilot projects testing the viability of diverting degradable waste through source-separated collection. In the first pilot, DSNY designated two areas of Brooklyn (Park Slope and Starrett City) as "Intensive Recycling Zones," where it asked residents to separate out three streams in addition to regular garbage: paper and textiles, recyclable containers, and food scraps and soiled paper (plus yard waste for Park Slope). The second pilot recruited institutions on Staten Island, such as hospitals and schools, and provided them with separate dumpsters for food waste. (For more detailed

information on these two pilots, as well as efforts to promote on-site composting, see *"Composting in New York City: A Complete Program History,"* on the Department's website at the following URL: www.nyc.gov/html/dos/html/recywprpts.html#2.)

The findings from these two pilots can be summarized as follows:

- The capture rate for the degradable fraction of the waste stream was only 41 percent in the Park Slope pilot. This means that out of the total amount of these materials known to be in the waste stream through waste characterization studies, 41 percent—less than half—was placed out for recycling collection (or conversely, 59 percent was still in the garbage).
- The capture rate for degradable waste was so low in the Starrett City pilot as to essentially be zero. Residents, especially those living in high-rise buildings, are reluctant to separate and store wastes such as spoiled food and dirty diapers for any period of time.
- Trucks collecting only degradable waste were not efficient, averaging around four tons per truck, per route (compared to the 10- to 12-tons-per-truck generally averaged during regular garbage collection).
- Without continuous education, retraining, and supervision, source-separated food-waste streams become contaminated. (This finding is reinforced by DSNY's experience with its curbside recycling program.)
- Since the Department collects institutional waste for free, institutions have few incentives to invest the time and effort required to maintain food-waste–separation programs.
- Many New York City institutions simply do not have the space for separate, food-waste dumpsters.

The appeal of MSW composting is that the entire waste stream, after curbside recycling, can be efficiently collected and delivered to a central facility, where nearly 100 percent of the degradable material is recovered and turned into usable compost. Since the degradable material is not set out separately, and is instead collected with the regular garbage, the Department can capitalize on the collection efficiencies it already achieves for refuse, without the monetary and environmental burden of sending out more collection vehicles.

Photo 2: Typical New York City garbage awaiting collection
The appeal of MSW composting is that the entire waste stream, after curbside recycling, can be collected efficiently and delivered to a centralized facility, where nearly 100 percent of the degradable material is recovered and turned into compost.

To say that the appeal of MSW composting is clear, is not to say that MSW composting is *always* the best approach for handling all predominantly degradable waste streams in the City. There are several locations, for

example, that generate significant quantities of degradable waste in a concentrated area—such as at the Hunts Point Terminal Produce Market in the Bronx, and the Rikers Island Correctional Facility—where source-separated composting makes sense. Since these locations offer the possibility of high capture rates, efficient collection routes, and manageable contamination levels, a source-separated, rather than mixed-waste approach, may be more appropriate.

Another example where MSW composting may be inappropriate is for fall leaves. City residents generate large volumes of fall leaves over a short time period, which allows for high collection efficiencies. In addition, homeowners normally bag leaves separately from the rest of their waste, making it relatively easy to obtain "clean" source-separated material. Finally, the innocuous nature of leaf composting also means that it can be done outdoors with simple equipment and at relatively low cost. For more information about the Department's source-separated-based composting programs, see *"Composting in New York City: A Complete Program History,"* on the Department's website at: www.nyc.gov/html/dos/html/recywprpts.html#2.

The opportunity to efficiently capture nearly 100 percent of the substantial, degradable fraction of the municipal solid-waste stream is a strong reason to consider MSW composting. But is the cost to process MSW into compost competitive with other waste-management options? And is the compost produced from such a process of a sufficient quality to have beneficial end uses? These, as well as other key questions, informed the Department's MSW-composting research project.

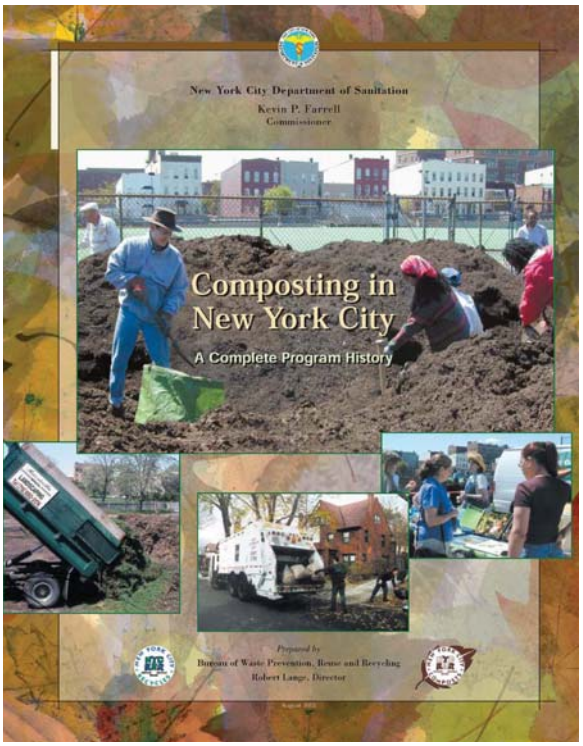


Photo 3: *Composting in New York City* report cover
Information about the Department's experience with source-separated and on-site composting can be found in this report, on the Department's website.

Report Structure

This report is divided into two main parts. The first part of the report presents the results from the New York City Composting Trials (held at Marlborough) and the survey of other, operating MSW-composting facilities. This includes the summary data from the extensive, compost-quality testing protocol for both the compost produced during the New York City Composting Trials, as well as compost sampled from the other surveyed facilities. The actual data are contained within Appendix F (New York City Composting Trials) and Appendix H (surveyed facilities) of this report, attached in portable document format (PDF) on the enclosed compact disk.

The second part of the report builds upon the learning of the first to describe a theoretical, pilot MSW-composting facility in New York City. The pilot facility design is in no way meant to be read as a blueprint, but is presented rather to

help the reader envision what such a facility might look like and how it might operate. More importantly, in order to calculate an estimated cost-per-ton to process New York City waste through MSW composting, it was necessary to assume specific throughput volumes, residue rates (and conversely disposal costs), as well as equipment, buildings, personnel, and power requirements.

Summary of Key Findings

Part One: Research Project

The first three chapters of the report begin with research questions. The key findings are summarized here as answers to those questions.

What quality of compost might DSNY expect to produce by composting samples of New York City residential and institutional waste?

> The compost produced from samples of New York City waste met New York State Department of Environmental Conservation (DEC) Class I compost standards in effect during the time of the survey, as well as the current pollutant-limit and product-use criteria (in effect as of March 10, 2003).

What is the quality of compost produced by existing MSW-composting facilities?

> Each of the surveyed facilities producing a finished compost made a product that met DEC Class I compost standards. The compost from each facility except one would meet the DEC's current pollutant-limit and product-use criteria. (The facility in question would need to lower the percentage of small pieces of non-degradable material in its finished compost from 3.9 to 2.0 percent.)

What is the potential recovery rate of New York City waste through MSW composting?

> The Marlborough facility recovered 50 percent of the sample New York City waste during the New York City Composting Trials. This recovery rate is in line with recovery rates achieved by the other MSW-composting facilities surveyed for this report, and makes sense given that the characterization of the New York City sample waste found 55.6 percent to be degradable. (Inevitably, some percentage of degradable material becomes entwined with non-degradable material and is discarded as residue.)

How well do other MSW-composting facilities perform, and what are the factors that affect the potential application of this technology in New York City?

> The four, MSW-composting facilities surveyed charge tipping fees between $45 and $85 per ton. These prices are competitive with other disposal options in the respective facility locations.
>
> The surveyed facilities recover between 49 and 70 percent of the solid waste that they process, with the balance disposed of as residue.

The facilities have been designed and are operated in such a way that they have successfully avoided odor problems with their residential and business neighbors.

Compared to MSW-composting facilities that employ a less mechanized approach, those facilities that actively manage (turn and water) their compost using mechanized processes for extended periods of time (50-plus days) produce a better finished compost, with regards to all horticultural and agronomic properties.

MSW-composting facilities could improve their performance by placing more emphasis on removing non-degradable items in the waste stream *before* they go through the initial MSW-composting process. This additional step would accomplish three important objectives:

- Increase recovery of recyclable items
- Decrease residue disposal costs
- Produce a cleaner final compost with wider application value

Part Two: Pilot Facility

The second part of the report builds upon both the results of the Composting Trials and the facility surveys to envision a theoretical, 300-ton–per-day, pilot MSW-composting facility for New York City. Through the Composting Trials and surveys the Department learned what makes a successful MSW-composting facility from a process perspective. In very general terms, this can be summarized as follows:

Successful facilities maximize recovery rates by increasing "desirable" outputs, which are quality compost, marketable recyclables, and loss of water vapor (shed during the composting process), while decreasing "undesirable" outputs, which are residual items requiring disposal.

Theoretical Pilot Facility Design
The theoretical pilot facility design incorporates two principal features (intensive, front-end materials recovery and extended, active composting), which distinguish it from current MSW-composting facilities, and would enable it to achieve success by the standard defined above.

- **Front-End Materials Recovery.** To maximize the recovery of the non-degradable, marketable recyclables that inevitably remain in the municipal solid-waste stream (even with curbside recycling programs), a pilot facility should employ front-end, materials-recovery equipment and manual sort lines. Such equipment would remove recyclables before waste went through the MSW-composting process. De-bagging and sorting all incoming MSW would not only increase the recovery of non-degradable recyclables, but would also decrease residue disposal costs and create a cleaner compost product.
- **Extended Composting.** A pilot facility should provide for 51 days of active, on-site composting of degradable materials. For perspective, this is more than twice the amount of time that material is actively composted at the Marlborough facility, where the New York City Composting Trials occurred. This extended composting time would allow for greater loss of mass in the decomposing material, as well as produce a better final compost product from a horticultural and agronomic perspective.

Projected Recovery Rates
A pilot facility's pre-composting, materials-recovery process should have three primary goals:

- Send as much paper and paper products (remaining in the MSW after curbside recycling program) to the composting process as possible.
- Prevent as much non-degradable material, especially glass and film plastic, from going to the composting process as possible.
- Recover as many non-degradable, recyclable items as possible.

Based on these goals and a detailed analysis of how each material fraction of the waste stream will move through a hypothetical pilot facility, the report concludes that the process could achieve a 70-percent recovery rate.

Projected Facility Cost
As noted, one of the goals of this project was to develop an estimated cost-per-ton with which to compare MSW composting to current and future export and disposal options. The Department accomplished this by supplying as many assumptions as possible about a hypothetical pilot facility to a financial analyst with experience in the economics of commercial-scale, MSW-composting and other MSW-handling facilities. The analyst took these assumptions and then calculated the per-ton costs for the projected life-cycle of the facility. Appendix J of this report presents the full, 30-year, life-cycle financial analysis for the pilot facility. The costs include:

- Capital development (including permitting and design work)
- Facility financing (debt service, etc.)
- Annual operation and maintenance (such as residue disposal and electricity)

The financial analysis concludes that the cost to DSNY to process MSW in a hypothetical pilot facility in the first year of operation would be approximately $75 per ton.

Conclusions

In 1992, the City's first comprehensive Solid Waste Management Plan (SWMP) recommended that the Department assess MSW composting more fully as a "major component of the waste management system," and encourage the City to build a facility so as to "extensively analyz[e] and carefully evaluat[e]" its potential.[3]

This report constitutes the full assessment that the SWMP recommends, and like the SWMP, also proposes that the City seriously consider building a pilot MSW-composting facility to learn more about this promising technology. Again, the pilot facility described in this report is a theoretical proposal. Should the City proceed with developing a facility, it would likely employ other types of equipment and be configured entirely differently than the facility presented herein. However, no matter what type of facility is built, it should have a number of discrete learning objectives (which are summarized in Table 5-1 of this report), and should have a set time period in which to answer some important questions.

If the pilot facility is able to operate successfully in a cost-effective, nuisance-free manner, and consistently produce a quality compost product with viable end markets, then the City might consider scaling up to a permanent facility. If the pilot facility is unable to accomplish these goals, then the facility should be dismantled, with the component equipment sold for reuse to other solid-waste–handling enterprises.

In conclusion, this report describes a waste-management option that would allow the Department to:

- Capture nearly 100 percent of the degradable fraction of the waste stream (as well as most recyclable items remaining in the garbage after curbside collection).
- Build upon existing waste-collection efficiencies.
- Require no additional public education since residents would not have to handle their waste any differently than they do currently.
- Potentially recover 70 percent of the waste stream for recycling (in addition to what is recovered through the existing curbside recycling program).
- Pay an equivalent cost-per-ton compared to current disposal options.

Given these important incentives, it seems well worth while to invest the time and funds necessary to build a pilot facility in order to extensively analyze and carefully evaluate these claims.