CHAPTER 2
COMPOST QUALITY

Summary

This section summarizes the data from the extensive, laboratory analyses the Department undertook to determine the quality of compost produced during the New York City Composting Trials. At minimum, the Department wanted to ensure that the compost made from New York City waste at the MSW-composting facility in Marlborough, Massachusetts (described in Chapter 1) met New York State Department of Environmental Conservation (DEC) standards—which it did. The Department also tested the compost produced by the four surveyed facilities to see how this compost fared against DEC regulations. Tables in this section present all of the relevant standards, as well as the compost test results.

Research Questions

As part of its research to determine if MSW composting is worthy of further consideration as a waste-management strategy for New York City, the Department set out to answer the following questions:

- What quality of compost might DSNY expect to produce by composting samples of New York City residential and institutional waste?
- What is the quality of compost produced by existing MSW-composting facilities?

To answer the first question, the Department sent samples of compost made from New York City waste at the Marlborough facility to a research laboratory for complete analysis. *The compost produced met DEC Class I compost standards (in effect during the time of the Trials), as well as current DEC standards (effective March 2003)*.

To answer the second question, the Department took similar compost samples from four other MSW-composting facilities currently operating in North America. *Each of the surveyed facilities producing a finished compost, made a product that met DEC Class I compost standards (in effect during the time of the survey)*. For more information about these facilities, see *Quality of Compost from Surveyed Facilities* below, and Chapter 3.

New York State Regulatory Issues

As the DEC regulates all solid-waste facilities and activities, both source-separated and non-source-separated composting operations fall under DEC jurisdiction. Subpart 360.5 of DEC's Conservation Rules and Regulations (6NYCRR) describes the terms under which a municipality or private company may compost solid waste and biosolids. The rules include a requirement that any compost produced by a facility be tested by a certified laboratory and meet specific quality criteria. Table 2-1 presents the DEC pollutant-limit and product-use criteria for compost made with MSW and/or biosolids. The full text of Subpart 360.5 can be found at the DEC website (www.dec.state.ny.us/website/regs/360l.htm).

Table 2-1
DEC Pollutant-Limit and Product-Use Criteria for MSW Compost

Excerpt from Section 360-5.5 Organic waste processing facilities for biosolids, mixed solid waste, septage, and other sludges:

(c) **Pollutant limits and product use.**

(1) A product that does not meet the criteria in this section must be disposed in accordance with this Part.

(2) For facilities that accept biosolids, septage, or other sludges, each waste source must not exceed the pollutant concentrations found in Table 4 of Section 360-5.10, unless the waste source is a minor (less than 10% of the total dry weight of sludges accepted) component of the input to the facility and a program is developed to identify and reduce the pollutant(s) that exceed the limits found in Table 4 of Section 360-5.10 for that waste source. *[See note 1 below.]*

(i) If a waste input, other than a minor source, contains metals at concentrations greater than those set forth in Table 4, the waste can not be accepted at the facility until the generator has implemented a pollutant identification and abatement program and compliance with the requirements of this paragraph has been demonstrated for a period of at least six continuous months. At least six analyses for total solids and the parameter of concern must be provided to demonstrate compliance.

(ii) Wastewater and partially treated biosolids or septage that are generated at one wastewater treatment facility and are further treated at another wastewater treatment facility prior to beneficial use are not considered waste sources subject to the criteria in this paragraph. The resultant biosolids or sludge generated for beneficial use are subject to this paragraph. For the purposes of this paragraph, dewatering is not considered treatment.

(3) The product must not contain pollutant levels greater than the values found in Table 7 of Section 360-5.10. *[See note 2 below.]*

(i) The addition of sawdust, soil, or other materials to the process or product for dilution purposes is not allowed.

(4) Any material added to the process must not contain pollutants in concentrations that exceed the levels found in Table 4 of Section 5.10. If kiln dust is used, the kiln dust must not emanate from a kiln that accepts hazardous waste.

(5) The product must not contain more than two percent total gross contaminants by weight (dry weight basis).

(6) The particle size of the product must not exceed 10 millimeters (0.39 inch) particle size, except for wood particles derived from the use of wood chips as a bulking agent or amendment in composting.

(7) A compost product must be produced from a composting process with a minimum detention time (including active composting and curing) of 50 days, unless an alternate means for achieving sufficient maturity is approved by the department.

(8) The product must be mature. The department may require process operating conditions including, but not limited to, longer aeration time and/or product use restrictions.

(9) An information label must be affixed to the product bag or, for bulk distribution, an information sheet or brochure must be provided to the user. The label or information sheet must contain, at a minimum, the following information:

(i) the name and address of the generator of the product;

(ii) the type of waste the product was derived from;

(iii) the average metal content of the product and the allowable metal levels (or a mailing address, e-mail address, or phone number where this information can be obtained); and

(iv) recommended safe uses, restrictions on use, application rates and storage practices intended to minimize the potential for nuisance conditions and negative surface and groundwater impacts emanating from the storage or use of the product.

(10) The product may be distributed for use on all crops except food crops. This restriction no longer applies 38 months or later after the pathogen reduction criteria have been met. If the product is stored for 38 months or longer, it can be distributed for use on food crops. If the product has been applied to the soil, food crops could be grown on the soil 38 months or more after product application.

(11) If the product will be marketed as a fertilizer or agricultural liming material in New York State, a license must be obtained from the New York State Department of Agriculture and Markets, if required.

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1. The pollutant levels from Table 4 of Section 360-5.10 are presented in Table 2-10 of this report.
2. The pollutant levels from Table 7 of Section 360-5.10 are presented in Table 2-2 of this report.

DEC Regulations in Effect During the New York City Composting Trials

The DEC updates its regulations periodically to reflect both changes in federal guidelines and State policy. The current Part 360 regulations went into effect on March 10, 2003. However, as the NYC Composting Trials took place during 2001, this report presents both the former as well as the current standards (see Table 2-2 for a comparison).

Perhaps the most significant change with regard to MSW-compost quality is that the current Part 360 regulations eradicate the previous distinction between a Class I and Class II compost

Table 2-2
Summary of Prior and Current DEC Part 360 Pollutant, Pathogen, and Physical Standards for MSW Compost

	Prior Standards (in effect during 2001)		Current Standards[1] (effective March 2003)	
	Class I	Class II	Monthly Average Concentration	Maximum Average Concentration
Pollutant Parameter (ppm)				
Arsenic	NS	NS	41	75
Cadmium	10	25	10	85
Chromium	100	1000	1000	1000
Copper	1000	1000	1500	4300
Lead	250	1000	300	840
Mercury	10	10	10	57
Molybdenum	NS	NS	54	75
Nickel	200	200	200	420
Selenium	NS	NS	28	100
Zinc	2500	2500	2500	7500
Total PCBs[2]	1	10	NS	NS
Pathogen Parameter (MPN)				
Fecal Coliform	NS	NS	<1000[3]	<1000[3]
Salmonella (per 44 dry grams)	NS	NS	<3[3]	<3[3]
Physical Parameter				
Particle Size (mm)	<10	<25	<10[4]	<10[4]
Percent Inerts	.50	NS	2.0[5]	2.0[5]

ppm = parts per million
MPN = most probable number per dry gram
NS = No Standard
< means not detected at the level noted.

1. Except where indicated, these parameters are from DEC regulations (6NYCRR) Section 360-5.10, Table 7.
2. There is no specific PCB limit in the new regulations since it is not found in Part 503 *(Standards for the Use and Disposal of Sewage Sludge)* of the Code of Federal Regulations. Should PCBs be a concern, a representative for the DEC indicated that the prior Class I standard would hold.
3. These parameters are from DEC regulations (6NYCRR) Section 360-5.5(b)(1).
4. These parameters are from DEC regulations (6NYCRR) Section 360-5.5(c)(4).
5. These parameters are from DEC regulations (6NYCRR) Section 360-5.5(c)(5).

product, and establish one set of criteria that *all* compost derived from solid waste and biosolids must meet. In addition, the new regulations introduce monthly average concentration levels, as well as maximum acceptable concentration levels. Other important revisions include additional testing (for arsenic, selenium, molybdenum, fecal coliform and *Salmonella*), changes to certain pollutant limits, and restricting levels of total gross contaminants to no more than two percent. (Contaminants in this case means the small pieces of glass, plastic, and other non-degradable items, which are referred to as "inerts" in this report.)

Quality of New York City MSW Compost

Section 360-5.5(c)(7) of the DEC regulations (see Table 2-1) states that an MSW-compost product must be "produced from a composting process with a minimum detention time (including active composting and curing) of 50 days, unless an alternate means for achieving sufficient maturity is approved by the department."

As the last chapter described, the Marlborough facility (located in Massachusetts where there is currently no minimum detention time requirement) composts its material on the air floor for 21 days, passes it through a half-inch screen, and then sends the material off-site for additional curing. Since it was not possible at an off-site location to safeguard the New York City compost against contamination or mixing with local material, the Department sent a cubic yard sample of the half-inch unders (immature compost that passed under the half-inch screen) for supervised curing at the research laboratory that performed the compost-quality analysis.

Again, the New York City material spent 21 days on the air floor at Marlborough. Therefore, in order to test what would be considered a finished (mature) product by DEC standards (i.e., a product composted and/or cured for at least 50 days), the laboratory continued to cure the compost another 38 days before taking samples. The results listed in Table 2-3 are from these Day 59 samples (21 days on the Marlborough air floor plus 38 days under supervised curing at the laboratory), except where noted. Appendix F contains the actual laboratory data sheets.

As discussed in Chapter 1, in order to produce a compost with the required particle size, the Department ran its material through the final screening equipment at Marlborough, even though this equipment was no longer in use. Therefore, the physical standard test results, listed in Table 2-3, are from samples of the New York City compost passing under the Marlborough facility final, three-eighths-inch screen.

As Table 2-3 demonstrates, *the compost produced during the NYC Composting Trials met DEC Class I compost standards (in effect during the time of the Trials), as well as current DEC standards (effective March 2003)*.

Quality of Compost from the Surveyed Facilities

The Department sampled material throughout the composting process at the four surveyed, MSW-composting facilities in order to make meaningful comparisons. In addition, samples of the primary screen unders (post-drum discharge) were removed from each facility and sent to the laboratory where they underwent further composting under controlled conditions. (See the

ANOVA section of Chapter 3 for more detail on this procedure.) Appendix H contains the laboratory data sheets for the four surveyed facilities.

The samples for pollutant testing were taken from the material that the lab composted under controlled, optimized conditions. Relative pollutant-concentration levels tend to increase with more complete degradation of organic materials. Therefore, sampling the lab-composted material enabled the Department to take the most conservative look at pollutant-concentration levels, and put all the facilities on an equal footing with regard to pollutant levels (i.e., facilities that more completely composted their material were not put at a disadvantage and vice versa). The laboratory took samples for these tests between 50 and 52 days after drum discharge, in order to simulate the DEC's 50-day, material-detention-time requirement.

Table 2-3
Comparing NYC Composting Trials Results with DEC Regulations

	Trials Results NYC Composting	Concentration Limits Prior DEC Class I	Current DEC Limits: Monthly Average Concentration	Current DEC Limits: Maximum Average Concentration
Pollutant Parameter (ppm)[1]				
Arsenic	4.9	NS	41	75
Cadmium	4.0	10	10	85
Chromium	40.8	100	1000	1000
Copper	150.8	1000	1500	4300
Lead	239.6	250	300	840
Mercury	1.0	10	10	57
Molybdenum	5.5	NS	54	75
Nickel	57.6	200	200	420
Selenium	1.4	NS	28	100
Zinc	568.0	2500	2500	7500
Total PCBs	<1[2]	1	NS	NS
Pathogen Parameter (MPN)				
Fecal Coliform	50[3]	NS	NS	<1000
Salmonella (per 44 dry grams)	<2[3]	NS	NS	<3
Physical Parameter[4]				
Particle Size (mm)	<10	<25	<10	<10
Percent Inerts	.50	NS	2.0	2.0

See Table 2-2 for abbreviations and DEC regulations citations.
1. Except where noted, the results are from Day 59 samples (21 days on the Marlborough air floor plus 38 days under supervised curing at the laboratory).
2. Results reported as an average from two samples taken from Day 147 material (the next available sample point for these parameters).
3. Results reported from sample taken on Day 80 material (the next available sample point for these parameters).
4. Results are from the laboratory characterization performed on the NYC material passing under the Marlborough facility final screen during the Composting Trials.

The samples for pathogen testing, as well as all tests that assessed agronomic and horticultural properties, were taken from what each facility considered its final compost product. The Department's consultant sent samples of this material directly from the respective facility to the laboratory for testing. These tests essentially measure how well a facility makes compost. If the Department had sampled the laboratory-composted material for these properties, it would in essence be looking at the optimized version of each facility's respective process. Again, the Department wanted to take the most conservative look at the MSW-composting process.

Table 2-4 presents the results of the tests for pollutants, pathogens, and physical parameters on finished compost from the surveyed facilities, and provides a comparison with the results from the New York City Composting Trials. The actual facility names are coded to provide anonymity. As Facility NRC does not currently produce a finished compost, tests were conducted on NRC Day 1 drum discharge. Because this is essentially a very raw, immature compost, fecal coliform levels are still high. The NRC data is not intended to represent a final compost product and is included here for comparison only.

The table also shows the previous DEC standards for a Class I compost, as well as the current standards. In general, New York City's Trials compost compares favorably with compost made at other MSW-composting facilities, with some pollutants at higher levels and others at lower ones. More importantly, *each of the surveyed facilities producing a finished compost, made a product that met DEC Class I compost standards (in effect during the time of the four-facility survey)*. With the exception of one facility, the compost produced by these facilities would also meet current DEC standards. (Facility NAL would have to reduce the percentage of inert material in its finished compost from 3.9 to 2.0.)

Other Test Parameters

Horticultural Properties

While the DEC does not provide specific standards for the horticultural quality of finished compost, it does require that facilities producing more than 50 cubic yards of compost per day analyze the following parameters and provide data on a monthly basis:

- total Kjeldahl nitrogen (TKN)
- ammonia (NH_3)
- nitrate (NO_3)
- total phosphorous (P)
- total potassium (K)
- pH
- total solids
- total volatile solids

The Department analyzed the compost produced in the New York City Composting Trials, as well as in the four surveyed facilities, for these parameters and several others considered

Table 2-4
Comparing Compost from the NYC Trials and the Surveyed Facilities with DEC Regulations

Pollutant Parameter (ppm)[1]	NYC Trials	Facility NQB	Facility NRC	Facility NAL	Facility NML	Prior DEC Class I Limits (ppm)	Current DEC Maximum Limits (ppm)
Arsenic	4.9	9.5	<4.0	6.41	3.05	NS	75
Cadmium	4.0	4.0	4.6	4.0	4.4	10	85
Chromium	40.8	42.0	26.2	73.2	45.3	100	1000
Copper	150.8	88.8	72.2	87.8	127.7	1000	4300
Lead	239.6	104.8	120.0	94.6	116.5	250	840
Mercury	1.0	0.5	1.7	1.8	0.6	10	57
Molybdenum	5.5	12.0	<9.1	5.17	4.75	NS	75
Nickel	57.6	35.4	40.4	36.3	57.7	200	420
Selenium	1.4	<5.5	<8.3	2.76	1.70	NS	100
Zinc	568.0	456.0	350.0	378.6	351.2	2500	7500
Total PCBs	<1	<1	<1	<1	<1	1	NS
Pathogen Parameter (MPN)[2]							
Fecal Coliform	50	209	8,529,000[3]	<2.7	<4.4	NS	<1000
Salmonella (per 44 dry grams)	<2	<1.1	<1.5	<1.3	<1.8	NS	<3
Physical Parameter[2]							
Particle size (mm)	<10	<5	NA[3]	<8	<10	<10	<10
Percent inerts	.50	.25	NA[3]	3.9	.50[4]	NS	2.0

See Table 2-2 for abbreviations and DEC regulations citations.
< signifies less than the minimum detection level for the particular parameter tested.
1. Testing performed on samples of lab-composted material, between 50 and 52 days after drum discharge from each facility. See notes to Table 2-3 for NYC sample-day information.
2. Testing performed on samples of finished compost shipped directly from each respective facility to the laboratory.
3. As Facility NRC does not currently produce a finished compost, tests were conducted on NRC Day 1 drum discharge. Since the material at this stage represents raw, immature compost, fecal coliform levels were still high. The NRC data is not intended to represent a final compost product and is included here for comparison only.
4. NML currently blends their final compost product with sand, a practice that would not be acceptable to the New York State DEC for inerts-measurement purposes.

relevant to product quality from a marketing or end-user perspective (such as moisture, density, and carbon-to-nitrogen ratio).

As noted, the agronomic/horticultural data (presented in Table 2-5) come from samples of what each facility considered its final compost. This varied significantly from facility to facility (see notes to Table 2-5). Chapter 3 provides a detailed discussion of operations at each of the surveyed facilities, however, it is important to note two points here.

First, as explained previously, Facility NRC did not produce a finished compost at the time of the survey, as the air-floor component of the facility was not yet built. Therefore, the testing for this facility was performed on drum discharge, which is essentially very raw (immature) compost.

Table 2-5
Evaluating Compost Quality from the NYC Trials and the Surveyed Facilities Based on Agronomic/Horticultural Properties

Parameter	NYC Trials	NQB	NRC[1]	NAL	NML[2]	Mulch Standard[3]
Total Kjeldahl Nitrogen[4] (% of total solids)	1.3	1.1	.83	2.2	.85	.15 - 1.0
Ammonia Nitrogen[5] (ppm)	2,243.0	198	248.5	1,407.5	2,233.5	<50
Nitrate[6] (ppm)	<2	<2	<2	<2	<2	10 - 100
Total Phosphorous (% of total solids)	.42	.20	.12	.23	.42	0.02 - 0.2
Total Potassium (% of total solids)	.30	.40	.26	.42	.21	0.1 - 0.5
pH	7.5	8.0	7.1	8.4	6.1	5.0 - 7.0
Total Solids (%)	76.5	78.3	52.1	73.5	44.4	NS
Total Volatile Solids[7] (% of total solids)	72	70.1	75.3	57.2	77.5	30 - 85
Nitrite (ppm)	<2	<2	<2	<2	<2	NS
Salinity[8] (mmhos/cm)	7.8	6.1	3.0	10.0	10.0	0.2 - 1.0
Density (lbs. per cubic yard)	775	716	783.5	884.5	1162.5	400 - 1200
Moisture (% of saturation)	23.5	21.8	47.9	53.2	55.6	35 - 85
Carbon-to-Nitrogen Ratio	25.9	33.45	48	13.4	38.9	35 - 150
Free Carbonates CO_3 (rating)	1	1.5	1	2	1	1 - 2
Solvita CO_2[9] (rating)	2	3	1.5	5	7	2 - 8
Solvita NH_3[9] (rating)	4	5	5	4	5	4 - 5
Calcium (% of total solids)	2.6	3.5	2.0	3.9	2.0	0.2 - 2.0
Magnesium (% of total solids)	0.38	0.22	0.16	0.35	0.18	0.04 - 0.4
Sodium (%)	0.56	0.30	0.39	0.63	0.38	<Potassium
Copper (ppm)	150.8	87.4	38.4	242	99.0	<1500
Manganese (ppm)	428	284	86.8	426	430	<1,000
Iron (ppm)	12,120	8,160	6,880	7,160	9,220	<12,000
Zinc (ppm)	568	482	218	660	400	<2,800

The unit of measurement follows most parameters in parentheses. Parameters in italics indicate those for which regular reporting is currently required. The lab data for the NYC Trials is found in Appendix F. Appendix H contains the lab data for the four-facility survey.

Final Product Sample Days: NYC (Day 59); NQB (Day 45); NRC (Day 1); NAL (Day 90); NML (Day 21).

< means not detected at the level noted.

1. Facility NRC did not produce a finished compost at the time of the survey, as the air-floor component of the facility was not yet built. Therefore, the testing for this facility was performed on drum discharge, which is essentially very raw (immature) compost.
2. NML facility finishes composting its material off site, where it blends material with sand before performing the final screen. Since the DEC would not allow such a dilution before testing, the lab performed the tests for the agronomic and horticultural parameters on samples of NML compost taken before it left the facility (Day 21). This product is therefore immature and these results do not represent the quality of NML's final product.
3. The Mulch Standard is not proscribed by any regulation, but is a part of the Rodale Quality Seal-of-Approval program for evaluating compost products, offered by the laboratory.
4. The Total Kjeldahl Nitrogen parameter is called "Organic-Nitrogen" in the lab data.
5. The lab reports Ammonia as Ammonia Nitrogen, labeled "Ammonium-N" in the data.
6. The Nitrate parameter is called "Nitrate-N" in the lab data.
7. The Total Volatile Solids parameter is called "Organic Matter" in the lab data.
8. The Salinity parameter is called "Conductivity" in the lab data.
9. Solvita is a registered trademark of the Woods End Research Laboratory, Inc.

Second, the NML facility finishes composting its material off site, where it blends material with sand before performing the final screen. Since the DEC does not allow such a dilution before testing, the Department chose to perform the tests for the agronomic and horticultural parameters of the NML compost as it left the facility (the last sample point before the material moved off site). This product is therefore immature and these results do not represent the quality of NML's final product, but are provided for comparison purposes.

Interpreting Agronomic/Horticultural Properties Data
Interpreting the agronomic and horticultural properties data is not as simple as interpreting the pollutants and pathogen data. In the case of pollutants and pathogens, there is an allowable limit, and a compost either meets the standard or it does not. With agronomic and horticultural properties, there is no absolute standard, but compost is evaluated depending on the intended end use. For example, what would be considered a good pH for mulch, might not necessarily be a good pH for potting soil. For a general guide to interpreting these results, see *Interpretation of Waste and Compost Tests,* attached as Appendix G.

The standard for "Mulch" provided in the far right column in Table 2-5 comes from the research laboratory that performed all of the tests associated with the New York City Composting Trials. Mulch represents one of the six recognized types of compost under the Rodale Quality Seal-of-Approval program—an independent quality-assurance program offered by the laboratory for evaluating and approving compost and soil amendment products.[1]

The intended uses of a mulch product are described as being for "surface application only, under shrubs or for non-growth purposes; 1"– 8" thick surface application for weed control, gradual nutrient release, and surface organic matter improvement." For a description of the other five recognized types of compost under the Rodale Quality Seal-of-Approval program, see page 5 of the lab's *Interpretation of Waste and Compost Tests* (Appendix G). The Department chose to analyze the compost produced in the New York City Trials and the four surveyed facilities against this standard, as this is the end use that best describes the types of projects that might utilize MSW compost.

Another important point to keep in mind when analyzing the agronomic and horticultural properties of a compost is that if an individual result falls out of the stated range for the standard, this is not necessarily a bad thing. For example, the fact that the nitrate levels for all of the composts fall below the range accepted for a mulch would not be considered a problem. However, if they deviated from the standard on the high end of the spectrum (i.e., >100 ppm), then this would be problematic. Likewise, for the composts listed in Table 2-5 that have higher amounts of phosphorous and calcium, this means that they contain more of these minerals than what is typical for a material being used as mulch. These levels are normally seen in compost used for topsoil blends, or other growth-oriented applications, where a user would want more minerals. Finally, the high iron level found in the NYC Trials' compost would not have negative implications and might actually be appreciated by a turf grower.

The standards are best read then as a guide. If most of the agronomic and horticultural parameters fall within the accepted range for a mulch, then a facility might want to adjust its operations to bring the few parameters that do not into conformance so that it could better promote its product for a specified end use. If the product can consistently meet the standards, then it can receive a seal of approval from the laboratory as a recognized "type" of compost. This makes marketing easier for the producer, and purchasing easier for the consumer, since the latter will know what they are getting without having to analyze the compost for themselves. For example, based on the data in Table 2-5, if operators at the four surveyed facilities wanted to receive a seal of approval for their respective products as a mulch-type compost, they would have to address the following three parameters: ammonia nitrogen, pH, and salinity.

Very high ammonia nitrogen levels in the NYC Trials compost, as well as those produced at facilities NAL and NML respectively, indicate that the nitrogen present in the material is not being stabilized by the available carbon. In fact, the carbon-to-nitrogen ratios for two of these three composts are on the low side, especially NAL. It is interesting to note that these three composts were made with biosolids (a direct source of nitrogen), while those at NQB and NRC were not. These results mean that either the facilities are using too much biosolids in relation to MSW, or that the material is not yet mature and requires further composting. These are both "corrections" that facilities can make.

The pH of compost should generally be neutral to slightly acidic (6.0-7.5), and efforts should be made to control it if it exceeds 8.5. However, if a facility was interested in making a mulch, operators would want to lower the pH to fall in line with the standard stated in Table 2-5 (pH 5.0-7.0). This can be accomplished by adding ammonium sulfate ($(NH_4)_2SO_4$—a chemical compound used for fertilizer that also occurs in nature as the mineral mascagnite). Research at Washington State University has shown that adding ammonium sulfate effectively lowers the pH of compost (as well as levels of ammonia nitrogen).[2]

Salinity represents the final parameter that facility operators would want to address in order to create a product that could earn a seal of approval for mulch. Soluble salt concentration is the concentration of soluble ions in solution and is usually expressed as the electrical conductivity (dS/m or millimhos per centimeter) of a saturated extract of compost. Soluble salt levels in compost can vary considerably, depending on the nature of the feedstocks and processing. Compost may therefore contribute to or dilute the accumulative soluble salt content in the amended soil. In general, knowledge of soil salinity, compost salinity, and plant tolerance to salinity is necessary for the successful establishment of plant material. For example, the final salinity of the amended soil for most turf and landscape plantings should be less than 4.0 dS/m, and for mulch it should be lower still (0.2-1.0). Most feedstocks generally produce compost with salinity levels greater than 4.0 dS/m, and most compost made with municipal feedstocks have a soluble salt concentration of 10 dS/m or below. The results for the NYC Trials compost and the four surveyed facilities are therefore typical given the nature of the feedstocks.

However, if they were to be used as a mulch, facility operators would want to lower the salinity level. This can be achieved by mixing the compost with other low-salinity materials (including other types of composts, such as tree bark) or by leaching with water. Compost with high-salts levels might also be applied well ahead of planting (fall or midwinter) to allow for natural leaching with rainwater.

When it comes to compost quality, facility operators need to work with end users in order to produce a compost that fits the intended application. Compost labeling and other programs that attempt to create recognizable standards (such as the Rodale Quality Seal-of-Approval) are relatively new in this country. While extra effort is involved to meet such standards, the appeal for a facility operator is that once they meet the standards, their product gains status as a recognized type of compost, which allows them to better target their product to end users. It also assures the end user of the quality of the product, which is particularly important for MSW composts.

Toxicity Characteristic Leaching Procedure

Since the non-degradable items removed by each of the various screening processes (after material has been discharged from the digester drum) would presumably have to be landfilled as residue, the Department wanted to determine if anything about the MSW-composting process (including mixing solid waste with biosolids) would in any way make this material hazardous for disposal (thereby necessitating different disposal practices than those used for regular garbage). Therefore, the laboratory performed a Toxicity Characteristic Leaching Procedure (TCLP) on samples of post-drum residue (material passing *over* the various screens), as well as on samples of immature compost discharged from the drum (labeled "2" Unders" in Table 2-6).

The TCLP simulates conditions in a landfill, whereby weak acids (replicating the effect of rainwater percolating through organic waste in the absence of oxygen) are washed over the material to determine if any heavy metals leach out. While this test is not commonly required in MSW-composting regulations, the Department wanted to take the most critical look possible at the results of the MSW-composting process.

The results of the TCLP test (Table 2-6) show that neither the residue nor the compost would pose a threat in a landfill. Five of the eight metals controlled by the U.S. Environmental Protection Agency did not register at all, while the remaining three were detected at levels far below the control limit.

Table 2-6
TCLP Results for the Post-Drum Residue of the New York City Composting Trials

Parameter (ppm)	2" Overs Day 1-3	2" Overs Day 3-5	2" Unders Day 1-3	2" Unders Day 3-5	½" Overs	⅜" Overs Facility	⅜" Overs Lab	EPA Control Limit[1]
Arsenic	—	—	—	—	—	—	—	5.0
Barium	0.36	0.26	0.43	0.45	.60	0.58	.48	100
Cadmium	—	—	—	—	—	—	—	1.0
Chromium	.05	—	0.1	0.06	—	.06	—	5.0
Lead	—	—	—	—	—	—	—	0.2
Mercury	.13	—	0.09	—	.07	—	—	5.0
Selenium	—	—	—	—	—	—	—	0.05
Silver	—	—	—	—	—	—	—	5.0

A dash signifies that there was no detection of the parameter in question at a minimum detection limit of 0.05 ppm.

1. Toxicity Characteristic Leaching Procedure is an EPA SW-846 analytical method (Method 1311). Control limits are set forth in 40CFR (Code of Federal Regulations) 261.4.

Inerts Levels and Characterization

DSNY carefully investigated the relative content of inert material ("inerts") in the compost made from New York City MSW, as well as that made at the four surveyed facilities. For the purposes of this report, inert material refers to small pieces (between 4-10mm or .152 - .39 inches) of plastic (such as shreds of plastic bags) or minute pieces of metal, glass, and textiles that fall under final screens and end up in the finished compost. To give an idea of the relative size of these inerts, four millimeters (4mm) is slightly larger than an eighth of an inch (⅛"), or the height of two, stacked nickels.

The laboratory conducting the analysis for the Composting Trials encountered two obstacles in measuring inerts levels:

1. There is no method describing how a lab is to determine inerts levels in any State or federal guidelines.
2. Each facility surveyed uses a different type and level of final screening, so the lab was faced with "comparing apples and oranges."

To address the first obstacle, the lab turned to *internationally* accepted standards to develop a measurement methodology. The methodology the lab used required that the compost first pass through a 10mm (⅜") hand screen before it was manually sorted down to a resolution of 4mm into the following five categories: glass, hard plastic, film plastic, metals, and textiles. While the DEC regulations do not list textiles as an inert material, DSNY chose to include it in order to be conservative in its evaluation of MSW composting. The lab chose the five categories of inert materials based upon prior compost-analysis experience.[3]

The differences in screen sizes between facilities was more difficult to overcome. Therefore, Table 2-7 lists next to the facility code the final screen size through which the material passed before it went to the lab. The results of the inerts characterization and percent composition come from an average of two composite samples. As stated earlier (Table 2-2), the updated DEC regulations limit the percent of inerts in finished compost to two percent. As Table 2-7 shows, all the finished composts, with the exception of facility NAL, fall below this limit.

It is not possible to speculate why the samples of NAL compost contained higher levels of inert material than samples of compost from the other surveyed facilities. However, factors that generally contribute to inerts levels include:

- The degree to which source-separated, curbside recycling programs remove non-degradable items before they reach the facility
- Whether or not collection trucks compact and break materials during transportation
- The efficacy of pre-drum sorting and post-drum screening of the resulting compost

For a point of comparison, the Department had the lab analyze compost produced at one of DSNY's leaf-and-yard-waste–composting sites. For anyone who has seen this compost, it is remarkably free of any visual contamination, and will serve to contextualize the inerts levels reported above. The results shown in Table 2-8 are an average of an A/B sample pair. Given that

Table 2-7
Inerts Characterization and Percent Composition of the <10mm Finished Compost

Inert Material (%)	NYC Trials (10mm)	NQB (5mm)	NRC[1]	NAL (8mm)	NML[2] (8mm)	Current DEC Total Inerts Limit (%)
Glass	—	0.1	NA	1.8	.4	
Hard Plastic	0.2	0.1	NA	1.2	.1	
Film Plastic	0.1	.05	NA	.4	—	
Metals	—	—	NA	.1	—	
Textiles	0.2	—	NA	.4	—	
Total	**0.50**	**0.25**	**NA**	**3.9**	**.50**	**2.0**

Results are an average of composite samples (A/B), except for facility NML data. For inerts-characterization data for the NYC Trials, see Appendix F. For the inerts data for the surveyed facilities, see Appendix H.
A dash signifies that there was no detection of the material in question.
1. NRC does not currently produce a finished compost product, so this analysis was not applicable.
2. NML blends its compost with sand before screening. This practice would not be allowed by the DEC. The results are provided for comparative purposes.

the input to the Department's leaf and yard-waste compost is source-separated leaves, brush, and grass from residents and landscapers, and the input to the NYC MSW-Composting Trials was mixed, residential garbage, the inerts levels achieved in the NYC Trials are fairly impressive.

Since the DEC has adopted the rigorous two-percent inerts level for MSW compost, it is imperative that the presence of this material be minimized, if not eliminated, in a final compost product. Beyond regulatory compliance, the outlets for finished compost are greatly enhanced when the product is visually free of contamination.

Biosolids

As explained in the *Receiving Biosolids and Liquid Waste* section of Chapter 1, the New York City Department of Environment Protection (DEP) currently produces 1,200-plus tons of biosolids per day, dewatered to 25-26 percent solids. Private contractors take these biosolids and pelletize

Table 2-8
Percent Composition of Inert Material: NYC MSW-Composting Trials vs. NYC Leaf-and-Yard-Waste Compost

Inert Material (%)	NYC MSW-Composting Trials Compost	NYC Leaf and Yard-Waste Compost	Current DEC Total Inerts Limit (%)
Glass	—	0.2	
Hard Plastic	0.2	0.1	
Film Plastic	0.1	—	
Metals	—	—	
Textiles	0.2	—	
Total	**0.5**	**0.3**	**2.0**

them into a fertilizer (42 percent), directly land apply them to crops (37 percent), compost them (13 percent), or alkaline stabilize them into an agricultural liming agent (8 percent).

The DEP produces dewatered biosolids at its eight Water Pollution Control Plants (WPCP) that possess dewatering capabilities. The other six WPCPs without dewatering capabilities either barge or pump sewage sludge via pipeline to the closest one that does. Figure 2-1 shows the locations of all 14 WPCPs.

The State DEC regulates the production and use of biosolids, and requires routine testing of incoming biosolids when used as a feedstock to MSW-composting facilities operating in New York State. Table 2-9 presents the parameters for which incoming biosolids must be analyzed.

Figure 2-1

Map of Water Pollution Control Plants in New York City

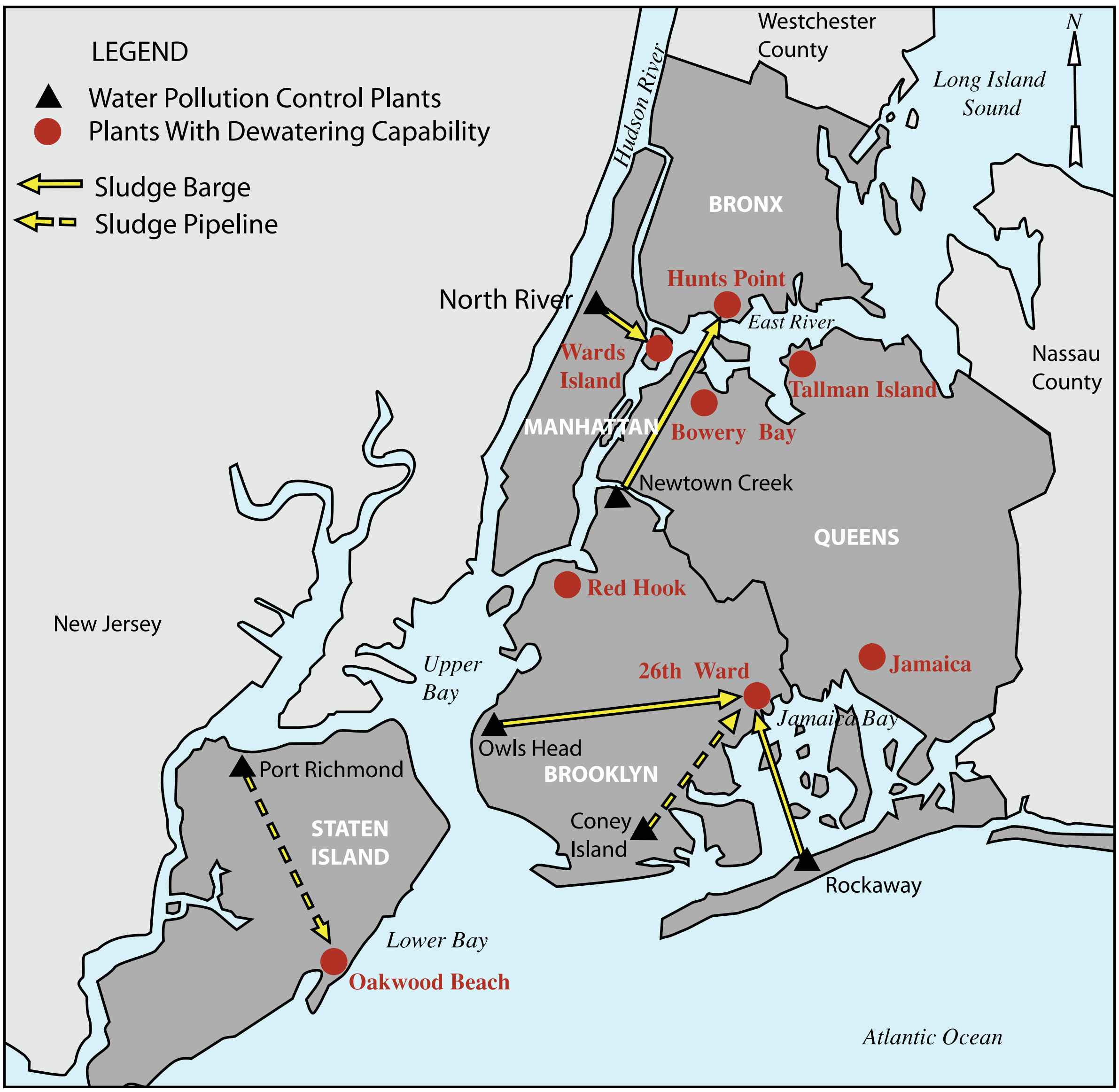

Table 2-9
Parameters for Analysis Required by the DEC for Biosolids as an Input to MSW Compost[1]

Group A	Group B	Group C
Total Kjeldahl Nitrogen	Arsenic	Extended Parameters
Ammonia	Cadmium	(see Appendix E)
Nitrate	Chromium (total)	
Total Phosphorous	Copper	
Total Potassium	Lead	
pH	Mercury	
Total Solids	Molybdenum	
Total Volatile Solids	Nickel	
	Selenium	
	Zinc	

1. These parameters are from DEC (6NYCRR) Section 360-5.10, Table 1.

For facilities accepting more than 1,000 dry tons of biosolids per year, the DEC requires monthly testing of the parameters listed under Group A and Group B, and *annual* testing for the extended list of 116 parameters listed under Group C. Appendix E of this report contains this extended list of parameters, including volatile organic compounds, acid-base-neutral compounds, pesticides, and PCBs.[4] While the DEC has not currently established limits for these 116 parameters, test results must be provided to the DEC for their discretionary review.

Table 2-10 presents the Group B parameters for which specific pollutant limits apply, along with the average results reported by the DEP for New York City's biosolids in 2001, and the data on the Marlborough biosolids used in the New York City Composting Trials. (As discussed in Chapter 1, due to logistical constraints, the New York City Composting Trials did not use New York City biosolids, but instead, made use of Marlborough biosolids.) For the laboratory results for the Marlborough biosolids used in the New York City Composting Trials, see Appendix F. For the actual DEP biosolids data, see Appendix E.

As Table 2-10 shows, some parameters in the DEP biosolids were at lower levels than those used in the New York City Composting Trials, while others were higher. Overall, the results for both biosolids fall well within DEC concentration limits. However, it would be prudent to monitor chromium, copper, lead, and zinc levels in the New York City biosolids since these were present at significantly higher levels than in the Marlborough biosolids used for the NYC Composting Trials.

Before generalizing about the quality of NYC biosolids, it is important to understand how the DEP results were derived. As noted, the DEP produces biosolids at eight of its fourteen WPCPs. Each of these plants produces different amounts of biosolids per day, and each plant's biosolids generally contain different levels of the parameters listed in Table 2-10. The DEP does not report these results on a citywide basis, both because of the relative complexity involved with weighting the results based on the actual amounts of biosolids each facility produces, and the fact that it does not make operational sense for the DEP to analyze biosolids generically. In order to generate the DEP data presented in Table 2-10, DSNY averaged the monthly biosolids data from each WPCP with dewatering capabilities for one year and then took a *non-weighted* annual average of all facilities together. This was the simplest way to derive one number for the purposes of comparison. For more information on how much biosolids each DEP facility actually produces, and the test data for each facilities' biosolids respectively, it is important to see Appendix E.

Table 2-11 presents the average results for the Group A parameters (listed in Table 2-9) reported by the DEP for New York City's biosolids in 2001, and the data on the Marlborough biosolids used in the New York City Composting Trials. These parameters are not pollutants, but pertain generally to the horticultural quality of the incoming biosolids and as such, the DEC does not set specific limits.

As Table 2-11 shows, the NYC biosolids and the Marlborough biosolids used in the NYC Composting Trials possess similar agronomic/horticultural qualities. However, a few differences are worth noting.

Table 2-10

Comparing NYC and Marlborough Biosolids Data Against DEC Regulations: Pollutant Parameters

Parameter (ppm)	DEP: NYC Biosolids Data[1]	NYC Trials: Marlborough Biosolids[2] Sample A	NYC Trials: Marlborough Biosolids[2] Sample B	Prior DEC Limits	Current DEC Limits[3] Monthly Average	Current DEC Limits[3] Maximum Average
Arsenic	4.1	15.0	<12	NS	41	75
Cadmium	5.1	0.2	2.0	25	21	85
Chromium	55.6	3.5	27.2	100	1000	1000
Copper	721	28.2	276.0	1000	1500	4300
Lead	191.9	24.8	32.0	250	300	840
Mercury	2.5	0.57	4.9	10	10	57
Molybdenum	12.3	<5	<31	NS	40	75
Nickel	34.6	59.6	47.6	200	200	420
Selenium	5.2	<5	<26	NS	100	100
Zinc	1002.6	328.0	372.0	2500	2500	7500
PCBs[4]	<1	<1	<1	10	NS	NS

NS = No Standard

< means not detected at the level noted.

1. The New York City biosolids data were derived by summing the annual averages of DEP data from January 2001-February 2002 for the City's eight dewatering facilities (Appendix E), and then averaging the sum of those eight. It is important to note that these averages were not weighted to account for the considerably different-sized output of each facility.
2. Appendix F contains the lab data for the Marlborough biosolids used for the NYC Trials.
3. These pollutant limits are from DEC (6NYCRR) Section 360-5.10, Table 4.
4. See note in Table 2-2 regarding PCB limits.

First, the NYC biosolids (containing 25.1 percent solids and 74.9 percent liquid) are significantly drier than the Marlborough biosolids (containing 15.6 percent solids and 84.4 percent liquid). This is most likely due to the fact that Marlborough treats its biosolids on-site (by pumping them directly to the MSW-composting facility), whereas NYC has to pay to export its biosolids. To reduce transportation costs, it is in the DEP's interest to remove as much water (and therefore weight) as possible from its biosolids. How the moisture level of New York City's biosolids would affect an MSW-compost "recipe" would be one of the learning objectives of any proposed pilot MSW-composting facility (see Chapter 5 for more information).

Second, the parameter *Total Volatile Solids* describes how much organic matter is present. In general, biosolids have an organic matter content of 70-80 percent. The organic matter content for New York City's biosolids (62.0 percent) is lower than Marlborough's (78.8 percent), and is on the low side in general. This may be due to the types of material coming into the New York City sewer system, the treatment process, or the way that the DEP handles fines or grit. Typically, if a fraction of the non-organic grit (such as sand, small pieces of gravel, etc.) finds its way into the biosolids, then proportionately the percent organic-matter content will be lower. While the actual reason that New York City's biosolids have a lower organic-matter content than Marlborough's is not known, it would be important to monitor the impact of this on compost quality, again, should the City go forward with a pilot MSW-composting facility.

Finally, the nitrate levels in the two biosolids appear to be different. However, due to the scale of measurement in this instance, the magnitude of difference is not important as both biosolids essentially have zero nitrates. For example, the 21.15 parts per million of nitrate in the NYC biosolids have to be read in relation to the total Kjeldahl nitrogen (TKN) level of 6.3 percent. This means that of the 6.3 percent of the biosolids that are nitrogen, .0003 percent (21.15 divided by 63,000) is present as nitrate.

Table 2-11

Comparing NYC and Marlborough Biosolids Against DEC Regulations: Agronomic/Horticultural Parameters

Parameter	DEP: NYC Biosolids Data	NYC Trials: Marlborough Biosolids
Total Kjeldahl Nitrogen (TKN) (% of total solids)	6.3	.76
Ammonia (NH_3)[1] (% of total solids)	1.5	.84
Nitrate (NO_3) (ppm)	21.15	3.0
Phosphorous (P) (% of total solids)	2.52	2.0
Potassium (K) (% of total solids)	.29	.20
pH	7.9	5.93[2]
Total Solids (%)	25.05	15.6[2]
Total Volatile Solids (% of total solids)	62.0	78.8[2]

For sources of lab data, see notes to Table 2-10. For nomenclature used in the lab data, see notes to Table 2-5.

1. Since the DEP reports ammonia levels as a percent (instead of ppm), the NYC Trials' value for ammonia was converted here for comparative purposes. The DEP data labels ammonia as NH_3, whereas the NYC Trials' data labels ammonia as Ammonium-N(NH_4-N). They are equivalent parameters.
2. These results are the average of two samples (A/B).

Compost Made from New York City Biosolids

As noted earlier, about 13 percent of the 1,200-plus tons of biosolids that New York City produces each day are collected and composted by a private contractor based in Pennsylvania. As the Department was unable to utilize New York City biosolids in its MSW-Composting Trials, it is important to know about the compost quality that these biosolids make.

The contractor collects biosolids from a number of WPCPs around New York City, including Oakwood Beach on Staten Island, the 26th Ward in Brooklyn, and occasionally, Tallman Island in Queens. The contractor owns two outdoor-composting facilities, approximately five acres each, in West Virginia. The one located in Wetzel County, West Virginia employs the aerated static-pile method to compost New York City biosolids exclusively. Facility operators lay down perforated PVC pipes and layer over them a blend of wood chips and biosolids. This material is then covered with finished compost to act as an in-place biofilter.

When the compost is finished and screened, the operator tests it against West Virginia, Pennsylvania, Ohio, Maryland, New York (all of the States where the compost is sold), and federal EPA standards to verify that the product is a Class A compost. The finished compost is called "Landscapers' Advantage Class A Compost," and is marketed as a soil conditioner for landscaping, tree farms, nurseries, sod farms, topsoil blending, land reclamation projects, parks, athletic fields, lawns, cemeteries, golf courses, and other horticultural applications. (See Appendix E for a copy of the promotional brochure.)

Tables 2-12 and 2-13 show the laboratory analyses for samples taken from the Wetzel County compost facility. Appendix E contains the lab results themselves. Table 2-12 presents the pollutants testing results (Group B parameters, for which specific limits apply), while Table 2-13 presents the data for the agronomic/horticultural properties (Group A, for which the DEC requires routine testing, but does not provide limits). The "Mulch Standard" in the right-hand column of Table 2-13 is not proscribed by law, but is provided for comparative purposes. See *Interpreting Agronomic/Horticultural Properties Data* earlier in this chapter for more information on this standard.

It is difficult to draw direct comparisons between the Wetzel County data (presented in Tables 2-12 and 2-13) and the data for either the compost made with Marlborough biosolids in the NYC Composting Trials, or for the uncomposted New York City biosolids themselves (Table 2-10). While the Wetzel County compost was made with New York City biosolids, the biosolids came from select WPCPs. The data for New York City biosolids in Table 2-10 presents an unweighted average of biosolids from *all* eight WPCPs. It is difficult to compare the Wetzel County data with the compost made in the New York City Composting Trials because the Wetzel County facility mixes New York City biosolids with wood waste, not municipal solid waste (MSW).

That being said, several things are interesting to note. Compost experts generally agree that the heavy metals in compost made with biosolids and MSW originate with the biosolids, not the MSW. While the Wetzel County compost was not made with MSW, it effectively demonstrates how heavy metals from biosolids "carry through" to the compost (assuming that the wood waste with which it was made has relatively low levels of metals).

Table 2-12
Quality of Compost Made with NYC Biosolids: Pollutant Parameters

Parameter (ppm)	Compost Made with NYC Biosolids[1]	Prior DEC Class I Limits	Current DEC Limits	
			Monthly Average	Maximum Average
Arsenic	5.4	NS	41	75
Cadmium	2.9	10	21	85
Chromium	40.0	100	1000	1000
Copper	569	1000	1500	4300
Lead	140	250	300	840
Mercury	1.0	10	10	57
Molybdenum	10	NS	40	75
Nickel	33.8	200	200	420
Selenium	0.5	NS	100	100
Zinc	637	2500	2500	7500
Total PCBs	<1	1	NS	NS

See Table 2-10 for abbreviations and sources for DEC regulations.
1. Based on test results provided by Wetzel County, West Virginia compost facility, which uses NYC biosolids exclusively in its operations.

Focusing on the four heavy metals that were potentially of concern—chromium, copper, lead, and zinc—the data shows similar levels in the Wetzel County compost as in the unweighted average of all New York City biosolids (Tables 2-12 and 2-13). The Wetzel County compost shows levels of 40 ppm for chromium, 569 ppm for copper, 140 ppm for lead, and 637 ppm for zinc. The respective levels of these heavy metals in the unweighted average of New York City biosolids are 55.6 ppm, 721 ppm, 191.9 ppm, and 1002.6 ppm.

That these four metals appear in higher concentrations relative to other metals, both in the Wetzel County compost and in New York City biosolids as a whole, demonstrates the principle of heavy metals carrying through from the biosolids to the compost. While *relative* levels of these metals are elevated, the *actual* levels will naturally be slightly lower due to dilution through mixing the biosolids with wood waste. To keep this discussion in perspective, it should also be noted that levels of chromium, copper, lead, and zinc were well within the more stringent DEC concentration limits in effect during the time of the NYC Composting Trials. Furthermore, in the recent changes to these regulations, the DEC raised the concentration limits for these four metals in particular.

With regard to the agronomic and horticultural properties of the compost made with New York City biosolids (Table 2-13), the results do not generally fall in line with the "Mulch" standard. Total phosphorous and pH are both higher than the standard. This would generally not be a problem for phosphorous, but depending on the specific intended end use, the pH might be a bit high. More importantly, the ammonia nitrogen level is very high and the total Kjeldahl nitrogen is also high. Elevated ammonia nitrogen levels could potentially be a concern if this compost was

Table 2-13
Quality of Compost Made with NYC Biosolids: Agronomic/Horticultural Properties

Property[1]	Compost Made with NYC Biosolids	Mulch Standard[2]
Total Kjeldahl Nitrogen (% of total solids)	3.02	.15-1.0
Ammonia[3] (ppm)	35,000	<50
Nitrate (ppm)	ND	10-100
Total Phosphorous (% of total solids)	2.17	.02-0.2
Total Potassium (% of total solids)	0.18	0.1-0.5
pH	7.8	5.0-7.0
Total Solids (%)	54.8	NS
Total Volatile Solids (% of total solids)	57.6	30-85

ND = None Detected
NS = No Standard
< means not detected at the level noted.
1. The DEC requires regular reporting of these parameters, but does not provide specific limits or standards that a compost product must meet.
2. This standard is not proscribed by law, but is a part of the Rodale Quality Seal-of-Approval program for evaluating compost products. "Mulch" represents one of the six recognized types of compost under this program.
3. The data for the Wetzel County compost, attached in Appendix E, reports ammonia (listed as "ammonia nitrogen") on a percent dry-weight basis. This table converts the result to parts per million in order to compare it to the Mulch Standard.

used straight as a mulch, rather than blended, for example, with topsoil. This is due to the fact that mulch is generally applied in fairly deep layers (six-plus inches) to kill weeds, and so much ammonia nitrogen could burn the plants that the mulch is intended to protect.

The company that makes and markets the Wetzel County compost recommends that users apply it when establishing new lawns and flower beds, when maintaining existing lawns, on nursery and house plants, and when mulching trees and shrubs. The promotional sheet that describes the Wetzel County compost product accompanies the biosolids data in Appendix E.