



CORNELL WASTE MANAGEMENT INSTITUTE

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KEY ASPECTS OF COMPOST QUALITY ASSURANCE

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The recent surge of interest in composting waste materials has led to new regulations to control contaminants and ensure environmental and human health and safety. Since regulations usually define the maximum total concentration of certain contaminants (e.g., heavy metals) permitted in the finished compost, facility managers must develop an appropriate testing program to ensure quality control and compliance.

Contract laboratories that analyze for contaminants should have an established quality assurance program for their chemical analyses, and a composting facility manager should obtain documentation that this program is adequate and being followed. But this is only one step of a multi-step process, and the facility manager's responsibility does not end here.

Accurate and precise analyses depend on a sequential chain of events, from the careful planning of a quality assurance program and selection of a large number of randomly selected samples to proper sample handling, chemical analysis, and data reduction and reporting. The quality of information generated at each step is entirely dependent on that of the previous steps. Clearly, if inappropriate samples are collected, even highly accurate chemical analyses will not produce useful information about compost quality. If sampling and

testing methods are not adequately recorded or reported, assuring the quality of the information generated—and thus, the quality of the compost produced—is impossible.

Since sample collection, handling, storage, and shipping are generally conducted by facility personnel, a quality assurance program that addresses these steps must be developed by each facility. The key steps in developing such a program are discussed below.

This fact sheet can not cover all the issues in detail. For example, although this fact sheet focuses on municipal solid waste (MSW) composts and heavy metal contamination, the issues raised are relevant both to other types of composts and to other measurable

compost characteristics such as toxic organic chemicals and plant nutrients. Hopefully, however, the examples and references provided will serve to stimulate greater attention to the tasks required to assure that compost is a consistently high quality product.

Defining Data Collection Objectives

To accurately assess quality and control costs, data collection objectives must be defined precisely. Different professionals will have different objectives. Researchers, for example, may want to determine the speciation (precise chemical form) of metals since such information is critical for determining

MSW COMPOSTING # 7 FACT SHEET SERIES

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the environmental fate of metals. Regulators, who require data to establish appropriate compost composition standards and ensure compliance, need to know the variability of contaminants.

Facility managers need data to establish sampling plans and achieve quality control. Their objectives will include optimizing the composting process to produce high quality compost at the lowest possible cost and to meet product standards. Generating the data needed to set standards or to establish a quality control program may require more intensive sampling than will be required for routine screening.

Compost users may have product quality concerns that are not covered by regulations. Physical characteristics such as water-holding capacity, for example, may be critical for some applications of compost. Customer objectives should also be addressed by a quality assurance program.

Some objectives will be shared by these different groups. These include assessments of compost nutrient content and availability, compost maturity, soluble salts, toxicity to plants, organic contaminants, trace metals, and inerts such as glass and plastic film.

Development of a Quality Assurance Plan

Quality assurance plans are being developed for some large-scale composting facilities and some states are beginning to provide regulatory guidance in this area. The Solid Waste Composting Council is also developing general guidelines that will propose limits for compost stability, soluble salts, pathogens, pH, heavy metals, inerts, and

film plastic and will recommend sampling protocols, analytical methods, and other elements of a quality assurance plan.

While these and other resources are useful, quality assurance plans must be tailored for each facility. The development of a quality assurance plan should include consultation with all parties involved in the program and an assessment of the objectives and needs of individual facilities.

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| <p>Key Steps in a Compost Quality Assurance Program</p> | <ul style="list-style-type: none"> • Define Data Collection Objectives • Develop a Quality Assurance Plan • Ensure Proper Sample Collection • Ensure Proper Sample Storage and Transport • Select Appropriate Analytical Methods • Record, Analyze, and Report Data |
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Ensuring Proper Sample Collection

Compost sampling is often a major source of uncertainty in compost test results. In fact, as analytical techniques improve, controlling sampling error frequently becomes the limiting step in assuring compost quality.

Because of the great variety of materials in feedstocks, MSW composts—and the distribution of contaminants within the composts—can be highly variable. Understanding this variability within and among compost batches is essential for establishing appropriate sampling methods and predicting the percentage of composts that will meet a given standard.

Without an adequate sampling plan, many questions about compost quality remain. If a single sample or a single composite sample is taken from a batch of compost, how well does this sample characterize the compost? If the concentrations of metals in this sample exceed the regulatory limit, must the whole batch be disposed

of? How similar would the metal concentration be in another sample from the pile?

Several aspects of sample collection—random sampling, ensuring an adequate number of samples, determining the frequency and timing of sampling, and subsampling—are crucial to answer such questions and ensure valid test results.

Random sampling: Since compost feedstocks may vary greatly in the waste material they include, potential contaminants will not be evenly distributed when the raw material enters the facility. Further, particular contaminants may be associated with certain

size fractions of the waste stream and thus, the resulting compost. For example, lead in compost produced from leaves or grass clippings is mostly in the form of fine dust deposited from air emissions. Hence, it is not surprising that a study of MSW compost demonstrated that metals, particularly lead, were most common in the 0-10 mm fraction. Finally, mixing and leaching may concentrate potential contaminants in particular regions of a batch.

For these reasons, it is crucial that multiple samples be collected from *randomly selected* locations within the batch. “Random sampling” means that every location in the batch has an equal chance of being sampled. Reports that “representative samples” were collected are common, but are not an adequate substitute for random sampling. In fact, the term “representative sample” should serve as a warning for those interested in quality assurance. All too often, it is used to mean a grab sample taken either intentionally from a certain region of the pile or windrow or selected haphazardly, but not se-

lected randomly. Without random sampling, no assessment of the bulk material is statistically valid, no matter how carefully the subsequent chemical analysis is performed.

Ensuring an adequate number of samples: Taking enough samples to accurately assess the mean concentration of a particular contaminant is one of the most neglected aspects of quality assurance programs. Given the heterogeneous nature of MSW compost, there can be considerable variation among samples from a single windrow, and a single sample might fall either above or below a regulatory limit simply due to chance.

In a recent survey of two operational MSW composting facilities, in Delaware and Minnesota for example, we found that the metal concentration varied considerably among ten randomly selected samples from single batches or windrows (see Figures 1 and 2). While the copper concentration, for example, was extremely homogeneous in the batch from one facility,

it varied from 300-1180 parts per million in the second. These data show the need for taking an adequate number of samples and for designing a program specific to the particular facility.

Measuring the variability in concentration of contaminants is particularly critical when the levels are near regulatory thresholds. In both Delaware and Minnesota the maximum allowable concentration for both copper and lead in Class I composts is 500 ppm. The average concentrations of both lead and copper in the 10 samples exceeded 500 ppm for both metals at both facilities, but at one facility many of the samples tested fell below that regulatory limit. Similar variations were found for lead, zinc, nickel, and other metals.

Unfortunately, no simple answer exists to the question "how many samples must be collected to assure an accurate assessment?" In the example above, calculations of the number of samples required to assess the true mean concentration for copper (with a 95% confi-

dence level) ranged from 3 at one facility to 313 at the other.

The number of samples needed depends on the accuracy required, the heterogeneity of the feedstock, and the degree of mixing during processing. Each facility should determine the number of samples required as part of its quality assurance plan.

Frequency of sampling: In addition to variability *within* a batch of compost, one must also expect variability *among* batches of compost. Feedstocks may vary considerably throughout the year, resulting in changes in contaminant levels. Thus, decisions must be made about the appropriate frequency of sampling. Is each batch of compost to be analyzed, or are samples to be collected only periodically throughout the year? The answer can only be rationally determined by testing the variation of potential contaminants over time to assess the variation present and design an optimal sampling regime.

Timing of sampling: Decisions must also be made about

Figure 1.

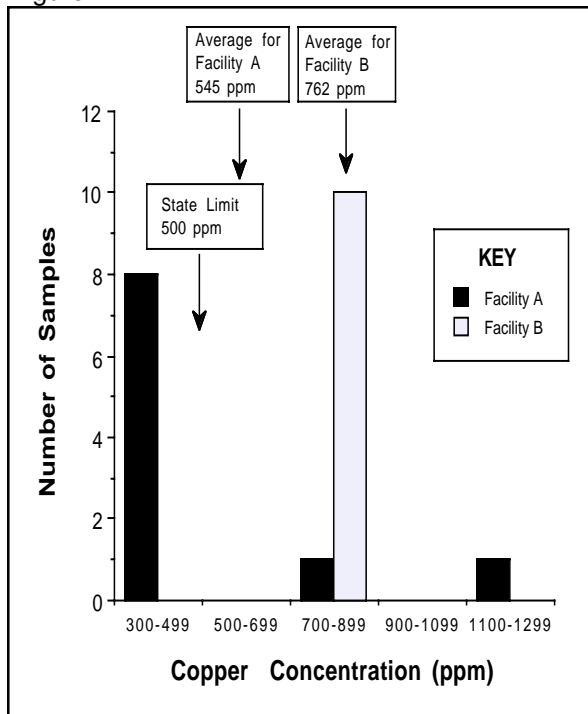
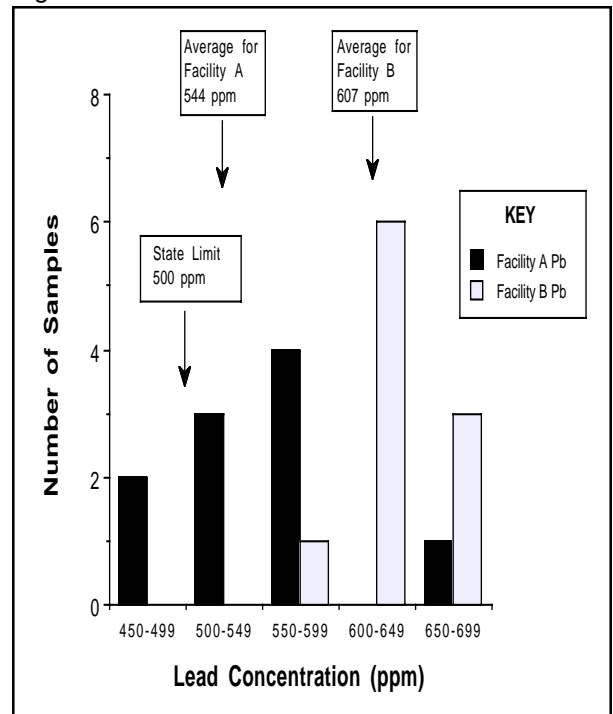


Figure 2.



when during the composting process the compost is to be tested. As the organic matter in the compost continues to decompose over time, the concentration of other components such as trace metals will increase on a dry weight basis.

Alternately, the data may be presented on an ash basis, that is, as a proportion of the weight of the non-organic component. Since this component will not decompose, this approach permits contaminant measurements to be made at any time in the process.

Sub-sampling: Because of the variability within compost samples, analytical laboratories must pay special attention to sub-sampling. As with the original sample collection, multiple sub-samples must be collected from randomly-selected locations. Whenever samples are taken from a larger batch for analysis, homogenization (e.g., mixing, grinding) is critical and verification of the effectiveness of such homogenization is needed.

Protocols for Sample Storage and Transport

Samples must be stored and transported such that no materials are added or removed that alter the analytical result. Generally, samples should be collected in clean plastic containers, refrigerated but not frozen, kept in the dark, and analyzed within a few days of being sampled. Appropriate protocols for sample handling are dependent on the objectives and can be particularly stringent for analyses of volatile chemicals and micro-organisms.

All samples should be permanently and unambiguously labelled, and a permanent record of all pertinent data be kept in a bound volume. The chain-of-custody for all samples should be specified, and it is useful to have one person supervise the entire process. (Details of

appropriate methods can be found in the EPA manual, see box.)

Selecting Appropriate Analytical Methods

Since regulations are based on total metal content in the compost, complete extraction of the metal from the sample is essential if compost quality is to be assured. One way to measure extraction efficiency is to use certified reference standards. A "reference standard" is material in which the concentration of metals or other parameters are known, enabling laboratory analysts to validate the accuracy of their analytical methods. Unfortunately, no such standards currently exist for MSW compost. The most appropriate substitute is probably an industrial sewage sludge standard from the National Institute of Standards and Technology (NIST BLR 146).

Such standards should be included in each laboratory procedure, along with appropriate spikes (known additions of the substance being analyzed) and blanks ("samples" without the substance being analyzed, used to test for contamination). The results of all analyses of standard materials should be reported along with other results to validate the data.

Unfortunately, such quality assurance data are rarely reported. A study of metal concentrations in MSW composts produced at sev-

eral North American facilities, for example, reported a high degree of variation in results from different laboratories. Routine use of reference standards can help validate analytical methods and avoid such disconcerting discrepancies.

Proper Data Record-keeping, Analysis, and Reporting

The measurements used to validate results, protocols used in sampling and testing, and details of the statistical methods employed should be reported along with the primary data so that the strengths and weaknesses of the data can be determined independently by the reader. The American Chemical Society has published useful guidelines for the evaluation of environmental data. The Environmental Protection Agency's (EPA) two volume set, "Test Methods of Evaluating Solid Waste Physical/Chemical Methods," presents useful statistical background as well as laboratory protocol and discussion of sampling issues.

Controlling Costs

Finally, the costs of sampling, analysis, and other aspects of a quality assurance program must be controlled. If the costs are prohibitive, the program will be difficult to implement. On the other hand, compost facility operators must be aware that consistent production of high

Useful Reference Materials

for Developing Compost Quality Assurance Programs

American Chemical Society. In *Analytical Chemistry*. 52:2242-2249. 1980. Guidelines for the acquisition and evaluation of environmental data.

Solid Waste Composting Council, 114 S. Pitt St., Alexandria, VA 22314. Guidelines for quality assurance, including proposed limits for compost stability, soluble salts, heavy metals and other parameters. In preparation.

U.S. Environmental Protection Agency. Office of Solid Waste and Emergency Response. *Test Methods for Evaluating Solid Waste*. — Field Manual SW-846. 1986.

Woodbury, Peter B. and Vincent T. Breslin. In *Biomass and Bioenergy* (Vol. 3, Nos 3-4, pp. 213-225, 1992). *Assuring Compost Quality: Suggestions for Facility Managers, Regulators, and Researchers*.

quality compost is critical to the success of all composting operations and that verification of compost quality will incur some unavoidable costs.

Although the following list is not comprehensive, it covers the most critical aspects of quality assurance for most metals.

References

See the fully referenced article in a special 1992 issue of *Biomass & Bioenergy* (Vol. 3, Nos 3-4, pp. 213-225, 1992), from which this fact sheet is extracted. A copy of that journal containing 11 articles on MSW composting can be obtained through the Composting Council, 114 S. Pitt St., Alexandria, VA 22314, for \$30.

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Recommended Sampling and Laboratory Practices to Assess the Trace Element Concentration of MSW Compost Products

- Obtain multiple composite samples from randomly selected locations within a pile or windrow.
- Use plastic containers for sampling and storage to avoid contamination; use field blanks ("samples" without the substance being analyzed) to test for such contamination during sample storage, transport, and processing.
- Analyze replicate subsamples of each composite sample, being careful to mix samples thoroughly and reduce particle size as needed.
- Use National Institute of Standards and Technology (NIST) or comparable standard reference materials to determine the accuracy and precision of the digest/analysis technique.
- Add a known concentration of the element of interest to compost digest solutions to check for potential matrix interferences.
- Carry reagent blanks throughout the digest and analysis protocols.
- Report metal concentrations of the compost on a dry weight basis.
- Report the ash content of samples.
- Report all quality assurance data along with sample data so that data quality can be independently evaluated.

Note: Additional care must be taken with some metals such as selenium and mercury that may volatilize during processing and for organic compounds that may volatilize or undergo chemical transformation prior to analysis.

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COMPOSTING RESOURCES

The following resources are available from the Cornell University Resource Center
8 Business & Technology Park, Ithaca, NY 14850 (Fax 607/255-9946)
(unless otherwise noted)

WRITTEN

Composting at Home, Let It Rot!! It's Nature's Way of Recycling —

Composting handbook available free from Cornell Cooperative Extension of Albany County, Martin Rd, PO Box 479, Voorheesville, NY 12186.

Composting to Reduce the Waste Stream: A Guide to Small Scale Food and Yard Waste Composting —

1991. Explains how to construct and maintain a compost pile. Outlines factors that affect the composting process including aeration, moisture and temperature. Illustrations, tables, diagrams, and step-by-step instructions for constructing compost bins. Produced by and available from the Northeast Regional Agricultural Engineering Service, Cornell University, 152 Riley-Robb Hall, Ithaca, NY 14853, 607-255-7654. Cost is \$7.

Composting: Waste to Resources —

36-page guide on the how-to's of composting for the beginner, including youth and educators, also included are two posters, and designs for compost systems. Available from Cornell Resource Center. Cost is \$8.

Fact Sheet and Viewpoint 2: "Yard Waste Composting," and "Composting as a Waste Management Strategy New Directions-New Questions," —

Produced by the Cornell University Waste Management Institute. 4 pgs. each. Cost is \$3, available from Cornell University Resource Center.

Home Composting Brochure — (Catalog code 329FFHSW) 1989. Produced by the Cornell Department of Agricultural Engineering. Available from Cornell University Resource Center. Cost is \$1.

Municipal Compost Management Home Study Program — 1991. An approach to assessing, designing, and managing a composting system for mu-

nicipalities. Developed by the Cornell University Waste Management Institute, with funding from ShopRite supermarkets. Available from the Home Study Program, Warren Hall, Cornell University, Ithaca, NY 14853, 607-255-2226. Cost is \$95.

Municipal Yard Waste Composting Operator's Fact Sheets —

10 fact sheets covering the different aspects of operating a composting facility. Produced by Department of Agricultural & Biological Engineering at Cornell University. Cost is \$4, available from Cornell University Resource Center.

On-Farm Composting Handbook —

1992. Comprehensive, up-to-date guide on many aspects of farm-scale composting. Produced by and available from the Northeast Regional Agricultural Engineering Service, Cornell University, 152 Riley-Robb Hall, Ithaca, NY 14853, 607-255-7654. 186 pgs, cost is \$15.

Yard Waste Management: A Planning Guide for NYS —

1990. Outlines the major considerations of municipal yard waste management, and provides the information needed to design an effective program. Prepared by Tom Richard, Agricultural & Biological Engineering, Cornell University. Available from NYSDEC, 50 Wolf Rd, Albany, NY 12233, 518-457-2051.

AUDIO VISUAL

Composting Exhibit — 1988. Produced by Cornell Cooperative Extension. Three-panel display and accompanying fact sheet on composting. True/false questions wired to light up, when correctly answered. Available on loan to NYS Cooperative Extension agents only, for \$20/day or \$40/7-day week from the Cornell University Resource Center.

Home Composting — 48 slides and script on backyard composting, developed by Cornell Cooperative Extension.

Available on loan to NYS Cooperative Extension agents from the Home Grounds Lending Library, 20 Plant Science Building, Cornell University, Ithaca, NY 14853, 607-255-3134.

Laminated Home Composting Posters, — set of 7:

- Poster defining "composting" and listing what materials can be composted.
- "Managing the Compost Pile," describing temperature, minimum pile size, and water requirements.
- "Life Cycle of the Compost Pile," which shows the living plant material, new compost, bacteria and fungi, partially decomposed compost, worms, beetles, and mites, and finished compost.
- Three-panel exhibit: "Home Composting-Which Method Is Best for You?"
- Three how to posters: "Heap," "Holding Unit," and "Turning Unit." Available from the Resource Center for \$100 or \$5/day base rental fee plus shipping.

Recycling Yard Waste, A Tour of Community Programs —

1991. 35-minute video showing how different municipalities are recycling yard waste through composting and chipping as an alternative to traditional waste disposal techniques. Produced to help local officials and citizens make informed choices about managing municipal yard waste. Cost \$48/loan \$18. Available from Cornell University Resource Center.

Turning Over an Old Leaf: The 20% Solution —

1992. 7-minute video produced to help citizens and local officials understand how composting and chipping yard wastes can save them money. Cost \$24/loan \$18. Available from Cornell University Resource Center.

Yard Waste Composting for Municipalities —

1989. Slide set produced by Nancy Dickson and Tom Richard of the Cornell Agricultural and Biological Engineering Department. Cost \$49/loan \$18. Available from Cornell University Resource Center.