Information Sheet No. 3-4

On-site Laboratory Testing for Quality

Information Sheet No. 3-4
Third Edition 2007

Inside This Sheet

ISBN 1-876850-02-7

Advantages of on-site laboratory testing

On-site testing and monitoring is the key to maintaining good *process control* at a composting site.

Regular testing and monitoring ensures that product quality is maintained and problems that arise are quickly identified and resolved in a short period of time.

Furthermore, testing and monitoring are integral components of a *quality management system*. These systems are based on a set of procedures an organisation uses to manufacture products of consistent quality (see Information Sheet No. 3-1).

Information Sheet No. 3-3 reviewed five field tests that can be easily performed at a composting site to achieve good process control.

Some simple tests, however, cannot be performed in the field. A small room or laboratory at a composting facility may be appropriate so more detailed tests can be done.

This information sheet reviews laboratory tests that can be done at relatively low cost at a composting facility.

Some equipment specified can be obtained from around the home. Some specialised equipment, however, needs to be purchased, but it should be remembered that a basic laboratory does not need to be expensive.

Tests reviewed in this Information Sheet include:

- moisture content;
- visible contamination;
- pH;
- electrical conductivity; and
- particle size grading.

Plate 1. Photograph of an on-site laboratory at a composting facility. This laboratory is primarily used for testing the quality of products manufactured before they are sold. Results produced by the laboratory complement those performed by an independent off-site laboratory (see Information Sheet No. 3-5).

Setting up an on-site laboratory

An on-site laboratory is an extremely useful addition to a composting facility.

An on-site laboratory allows a composting facility to perform simple tests at low cost that may otherwise need to be done by an off-site commercial laboratory.

Apart from significant cost savings, an on-site laboratory can process samples and generate test results in a short period of time.

This is particularly important if immediate decisions regarding feedstock receival, processing or product formulation need to be made.

Testing and monitoring at all stages in a composting facility gives the operator much more control and confidence regarding the operation and management of a composting operation.

It should be remembered that final product testing needs to be performed by an independent off-site laboratory. This is particularly so when a manufacturer produces product under a product certification system — in this instance, independent verification of product quality is mandatory.

Furthermore, independent off-site product testing for quality gives customers a greater level of confidence in product offered for sale (see Information Sheet No. 3-5).

Tests described here, however, can be considered to be in-process tests.

The tests are not hazardous, so no special laboratory design is necessary.

Ideally, the room designated as an on-site compost laboratory should have windows for ventilation, with good lighting and adequate benches for conducting tests and storing equipment and samples.

The laboratory should either be a secure space with restricted access, or have materials and equipment stored in a secure lockup cabinet to prevent misuse and/or damage from unauthorised personnel.

The room should be kept around 20°C, but this is dependent on resources available for an air conditioning system.

Shelving up to eye-level on the walls is convenient for storing equipment and consumables.

A sink with running water is also needed to wash containers and glassware.

All on-site laboratories should contain a complete and up-to-date Work Cover approved first aid kit and fire extinguisher/blanket for any emergencies that may arise.

A 20 L plastic bucket should be kept in the room to dispose of sample waste. In addition, tissues and paper towelling should be kept in a convenient place to clean tips of electrodes and to contain liquid spills.

Safety precautions, of course, should be observed for all equipment used in the laboratory.

Other safety precautions that need to be observed in a laboratory regarding the use of gloves, safety glasses and hygiene are reviewed in the box to the right.

Sampling

The first step in testing is to obtain a representative sample, or to sample from a representative location.

Recommended sampling strategies can be seen in Information Sheet No. 3-3, and further described in Information Sheet No. 3-11.

Testing safety tips

The tests discussed here are not hazardous, but a few safety precautions need to be observed.

Gloves
These should be worn when hot containers or sharp objects are handled (e.g. glass during visible contamination assessments).

Safety glasses
Safety glasses or goggles need to be worn during all testing procedures.

Ventilation
All testing areas, particularly enclosed rooms, need to be well ventilated.

Equipment precautions
Observe all safety precautions associated with equipment used for sampling and testing.

Hygiene
If any materials are handled, including raw feedstocks and compost during field testing procedures, hands should always be washed with soap and water afterwards.

First aid kit
A Work Cover approved first aid kit should always be conveniently located in the work place.

Fire extinguisher
A Work Cover approved fire extinguisher and fire blanket should always be conveniently located in the work place.

Test 1: Moisture content

Moisture content is the portion of a material's total weight that is water. It is often expressed as a percentage. The non-water portion of a material is referred to as dry matter.

Moisture content is an important variable when preparing feedstocks for composting. Optimum moisture content for composting is between 55 and 60% (Miller, 1993).

Field tests, such as the 'fist test' (see Information Sheet No. 3-3) can be used to estimate moisture content—such as whether a recipe is 'adequate', 'too dry' or 'too wet' for composting.

The fist test, however, cannot be used to accurately determine how much water is required to increase the moisture content of a compost recipe, windrow or material contained within any other system.

To do this, a more accurate estimate of moisture content is required. The test described here is based on the use of an oven or microwave to assist with drying so that moisture content can be quickly determined.

Materials:

- Microwave oven (~600W), if samples do not contain pieces of metal or plastic; or a drying oven (operating at ~105°C) (Plate 2).
- One balance (max 6 kg, accurate to 1 g).
- Microwave proof plastic dish, preferably 25 cm in diameter and 5 cm in height (if a microwave is used for drying); or a metal dish (if an oven is used for drying). All containers need to be clean and dry.
- 0.5 L of fresh test sample.
- 1 metal spoon.

Method:

1. Determine mass (g) of a dish (m_1) that is large enough to hold 0.5 L of material (Plate 3).

2. Place the 0.5 L sample in the dish and determine combined mass (g) of dish and product (m_2).

3a. Microwave drying method: Place the dish of moist material in a microwave initially on full power for 5 minutes. Remove and record weight. Reheat sample in 5 minute intervals until a constant weight is obtained. Check that charring or burning does not occur (if so, restart method). Determine mass (g) of dish plus dried product (m_3).

3b. Oven drying method: Place the dish of moist material in the oven set at 105°C. Leave it there until its mass is constant (~24 hours). Determine mass of the dish plus dried product (m_3).

Calculation:

$$\% \text{ Moisture} = \frac{m_2 - m_3}{m_2 - m_1} \times 100\%$$

A procedure for adjusting the moisture content of material within a composting system can be found in Recycled Organics Unit (2002).

Figure 1. Specialised equipment suppliers and approximate prices

Balances

- Ohaus CT 6000 portable laboratory balance, 6000 g maximum capacity, accurate to 0.5 g. Digital LCD display and tare function. Crown Scientific, NSW. Cost $1 113.29 (see Plate 2).
- BSE digital platform scale, 60 kg maximum capacity, accurate to 50 g. Digital LCD display and tare function. Wedderburn, NSW. Cost $ 785.40 (see Plate 4).

Bottles, measuring cylinders, funnels and filter papers

- Shaking bottle, 250 mL capacity, wide mouth, plastic. Crown Scientific, NSW. Cost $3.70 (see Plate 8).
- Measuring cylinder, 250 mL capacity, plastic, printed graduations. Crown Scientific, NSW. Cost $30.15 (see Plate 8).
- Filter funnel, plastic, unbreakable, 120 mm top diameter. Crown Scientific, NSW. Cost $3.02 (see Plate 8).
- Filter papers, Whatman No. 1, pack of 100. Crown Scientific, NSW. Cost $48.66 (see Plate 8).

Sieves

- Endecotts 450 mm diameter, 16 mm aperture plated steel sieve. High sides (300 mm). Crown Scientific, NSW. Cost $325.78 (see Plate 4).

pH and electrical conductivity meters

- Agritest combined pH and electrical conductivity meter kit. Comes with carry case and calibration solutions. Crown Scientific, NSW. Cost $211.20 (see Plate 8).

Plate 2. Equipment for determining moisture content. A laboratory drying oven (not included in the equipment package, though this particular drying oven — Heraeus Series 7000 function line is available from Radiometer) (left), balance (centre) and metal spoon and weighing dishes (right). Please note that the metals drying dishes (baking trays) are available from any good hardware store.

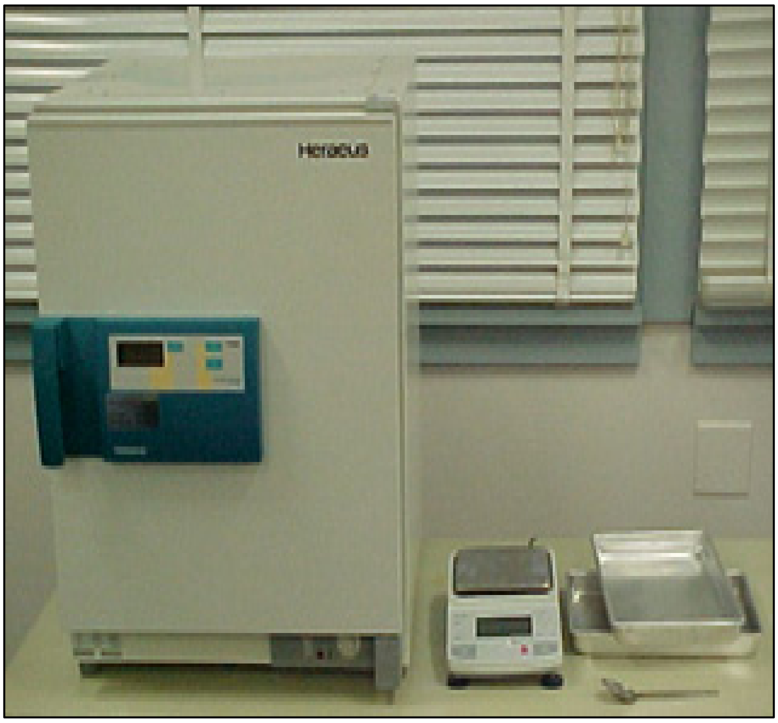

Plate 3. Procedure for determining the moisture content of a sample. Taking the mass of a clean and dry metal weighing dish (far left), taking the mass of a fresh sample of compost before placement in the oven (left), placing the dish and sample into the drying oven for ~24 hours (right), and recording the mass of the dry sample and weighing dish (far right).

Definitions

Process Control

Stringent and documented monitoring of all critical control points in a composting operation so as to minimise defects and make products which can be guaranteed to customers.

Quality Management System

Is a set of procedures an organisation establishes to guarantee it products will satisfy consumers.

Moisture Content

The fraction or percentage of a substrate comprised of water. Moisture content equals the weight of the water portion divided by the total weight (water plus dry matter portion).

pH

A measure of the concentration of hydrogen ions in a solution. pH is expressed as a negative exponent. Material that has a pH of 8 has ten times fewer hydrogen ions than a material with a pH of 7. The lower the pH, the more hydrogen ions are present, and the more acidic the material is. The higher the pH, the fewer hydrogen ions present, and the more basic it is. A pH of 7 is considered neutral.

Electrical conductivity

A measure of a solution's ability to carry an electrical current; varies both with the number and type of ions contained in the solution. Usually measured in deci-siemens per metre (dS m^{-1}).

Test 2: Physical contamination

Excessive contamination of feedstocks received with glass, metal, plastic, stones and clods of clay is the most common cause of variable product quality.

Analysis of contamination is a key step in being able to accept or reject a batch of material.

It is difficult to perform a comprehensive assessment of contamination at the gate, except for visually inspecting for large contaminant items, such as plastic bags, glass bottles, carpet etc.

The methods reported here are for determining the visible contamination of the final product, whether it be a mulch, soil conditioner, potting mix, soil etc.

Standards Australia (2003) details a physical contamination procedure in AS 4454 for Composts, Soil Conditioners and Mulches (Appendix H). Two simpler procedures are mentioned here to enable operators to determine the contamination level of final products in a short period of time.

The method reported here measures physical contamination on a mass basis. A limitation of this method is that products contaminated with significant quantities of very low density plastic, such as that from shopping bags, will show very low levels of contamination.

In most cases, however, this rarely occurs because feedstocks with such high levels of physical contamination are rejected at the gate.

Materials:

- One 20 L bucket (Plate 4).
- One two litre ice-cream container.
- One sieve with apertures of 16 mm.
- Metal spoon or tweezers.
- Plastic sheeting.
- One large digital platform scale (max ~60 kg, accurate to 50 g).
- One small balance (max 6 kg, accurate to 1 g).
- ~25 L of fresh test sample.

Method

1. Weigh the empty plastic bucket on the large platform scale. Record mass in kg (m_1) (Plate 5).
2. Weigh the ice-cream container on the small balance. Record mass in kg (m_2).
3. Fill the plastic bucket with the test sample. Weigh the entire bucket and contents on the large platform scale. Record mass in kg (m_3).
4. With the 16 mm sieve, screen out the small-sized fraction onto plastic sheeting. With a spoon or tweezers, remove all visible contaminants (e.g. glass, metal, plastic, stones and clods of clay) and place them in the ice-cream container. Dispose of uncontaminated material (Plate 6).
5. Contaminants >16 mm in size can be removed by hand (with gloves if sharp object are present). Place the contaminants in the ice-cream container as before.
6. Record mass of the ice-cream container and contaminants in kg (m_4) on the small balance. If it weighs more than 6 kg, use the large platform scale.

Calculation:

$$\text{\% Physical Contamination (by mass)} = \frac{m_4 - m_2}{m_3 - m_1} \times 100\%$$

Acceptable levels of physical contamination in final products depends on the composting facility, contracts for receival and customer requirements.

Excess contamination is often removed by screening prior to sale of the product.

A guide to acceptable contamination levels in composts, soil conditioners and mulches is given by Standards Australia (AS 4454, 2003) in Table 3.1.

Plate 4. Equipment for determining the physical contamination of a final product.

Plate 5. Taking the mass of a 20 L bucket on the platform scale (left) and filling the bucket with a representative sample of product for visible contamination assessment (centre). The mass of the bucket and product is taken (right).

Plate 6. Screening of the sample through a 16 mm sieve onto plastic sheeting (left) and removal of contaminants with a metal spoon from the sieved fraction (centre). The contaminants are placed into an ice-cream container of known mass (right).

Plate 7. Removal of large contaminants from the material remaining on the sieve (left) and measurement of the total mass of contaminants in the sample (right).

Test 3: pH

pH is a measure of how acid or alkaline a material is. pH influences the availability of nutrients and plants vary in their tolerance to pH.

Measurement of pH is an important process control strategy, particularly for compost recipe preparation and product formulation.

New feedstocks processed at a facility should be tested for pH to determine whether they can be composted in their present condition. Such tests will establish whether amendments need to be added to adjust pH.

A colorimetric field test procedure for measuring pH is reviewed in Information Sheet No. 3-3. The procedure used here provides more accurate results using a combined pH and electrical conductivity meter.

Materials:

- One 2 L ice cream container (no lid required) (Plate 8).
- One 250 mL plastic bottle with screw type lid.
- One 250 mL plastic measuring cylinder.
- distilled or deionised water.
- Combined pH and electrical conductivity meter, accurate to 0.2 pH units.
- One clean disposable drinking cup;
- One Whatman No. 41 filter.
- One plastic funnel.
- One metal spoon.
- 1 L of fresh test sample.

Method:

1. Place about 1 L of fresh sample into the 2 L ice cream container.
2. Moisten sample with distilled or deionised water until water can just be squeezed from it with your hand (Plate 9).
3. Mix sample with a metal spoon and ensure all of sample is moist.
4. Place 100 mL of the sample into the 250 mL plastic bottle. Drop from a height of 5 cm five times to consolidate the sample. Top up with more sample to reach 100 mL if required.
5. Add deionised or distilled water with the measuring cylinder until the 250 mL mark is reached, indicated on the side of the bottle (Plate 10).
6. Seal the bottle and shake by hand for a few seconds. Repeat 4 more times at 20 minute intervals.
7. Fold a filter paper into the fan style and insert into funnel. Put end of funnel into a plastic disposable cup (Plate 11).
8. Slowly pour off the liquid (from the 250 mL bottle in step 6).
9. Turn on the pH meter and calibrate if necessary (see manufacturer's instructions).
10. Insert pH probe into the extract and record reading once it has stabilised.

In general, organics most suited to composting have a pH between 6 and 8, and final products should have a pH that conforms to user requirements or a relevant product standard (e.g. 6.5-7.0).

If feedstocks have a pH of less than 5, lime (calcium carbonate), hydrated lime (calcium hydroxide) or quicklime (calcium oxide) may need to be added to neutralise acidity present. If pH is greater than 9, an acidifying agent may need to be added to the material (e.g. elemental sulfur).

Plate 8. Equipment for determining the pH of a sample of material.

Plate 9. Moistening the sample of material to field capacity (left), and placing a 100 mL portion of the sample into a 250 mL graduated shaking bottle (right).

Plate 10. Addition of distilled water into the bottle (left), and shaking of the bottle by hand (right).

Plate 11. Filtering the suspension through a filter placed in a funnel (left) and insertion of the combined pH and electrical conductivity meter into the filtered extract (right). Note that not all of the liquid in the bottle needs to be filtered before the pH test can be done. Just enough liquid to cover the tip of the pH electrode in the cup is required (~2 cm deep).

Test 4: Electrical conductivity

Measurement of *electrical conductivity* is an important process control strategy for the same reasons as outlined above.

Electrical conductivity is a measure of how salty a material is. Composts high in salts can kill plants by causing water stress and ion toxicities.

The amount of soluble salts in a material can be determined with a conductivity meter which passes a small electric current between two electrodes. Electrical conductivity increases as the concentration of soluble salts increases.

The electrical conductivity method reported here is based on Appendix A of Standards Australia AS 4454 (2003).

New feedstocks used at a facility should be tested for electrical conductivity to determine whether they can be composted and formulated into quality products.

Such a test may indicate that highly saline feedstocks cannot be composted as they will raise the electrical conductivity of the final product to an unacceptable level.

Alternatively, saline feedstocks can be blended with less saline feedstocks to reduce the overall electrical conductivity.

The maximum electrical conductivity of a feedstock accepted at the gate will depend on the nature of products generated by the facility and customer requirements.

Materials:

- One 2 L ice cream container (no lid required).
- One 250 mL plastic bottle with screw type lid.
- One 250 mL plastic measuring cylinder.
- distilled or deionised water.
- Combined pH and electrical conductivity meter accurate to 0.05 dS/m.
- One clean disposable drinking cup;
- One Whatman No. 41 filter.
- One plastic funnel.
- One metal spoon.
- 1 L of fresh test sample.

Method

1. The same filtrate (solution) produced by the pH test can be used for this test. If the pH test had not been done, please follow steps 1 through to 8 of the pH test.
2. Turn on the combined pH and electrical conductivity meter and calibrate if necessary (see manufacturer's instructions).
3. Insert electrical conductivity probe into the filtered extract and record reading once it has stabilised. The reading should be recorded in dS/m (Plate 12).

Note that some electrical conductivity meters read in mS (actually, mS/cm). Because one mS/cm equals one dS/m, readings in mS/cm can be written as dS/m without any conversion.

Incoming feedstocks with an electrical conductivity in excess of 2 dS/m need to be noted as they produce quite saline composts.

Such products need be applied in restricted amounts to soils, as plants differ in their sensitivity to salinity.

Standards Australia (AS 4454, 2003) in Section 2 outlines the labelling requirements for different products containing recycled organics for electrical conductivity.

Processing of saline feedstocks will depend on the quality of composts produced, and customer requirements.

Saline composts can be blended with other less saline products, thereby diluting the salt content and reducing the electrical conductivity of the final products. This can be done during the product formulation stage of composting.

Plate 12. Measurement of electrical conductivity in the same filtered extract prepared in the pH method.

Test 5: Particle size grading

Particle size grading is an important aspect of product formulation. Coarse particles in products designated as soil conditioners, fine mulches, potting mixes or soils for example, may be unacceptable to consumers.

Particle size grading can indicate the efficiency of the screening system in place.

The method reported here is based on Appendix F in Standards Australia AS 4454 (2003).

The method uses a metal sieve to separate particles based on size.

Materials:

- One sieve with apertures of 16 mm (Plate 13).
- One small balance (max 6 kg, accurate to 1 g).
- Metal drying dish.
- Plastic sheeting.
- 1 L of test sample.

Method

1. Record the mass (g) of the clean and dry metal drying dish on the small balance (m_1).
2. Select a representative sample of product (1 L) and spread out on the metal dish and allow to air dry for at least 5 days if wet.
3. Record mass (g) of dish with the air dried sample on the small balance (m_2).
4. Place the sample on the 16 mm sieve and shake in +a horizontal plane for 1 minute over plastic sheeting (Plate 14).
5. Empty the particles retained in the sieve back into the metal dish and record its mass (g) on the small balance (m_3).

Calculation:

$$\text{Particles with a diameter} > 16\text{ mm (\% of product)} = \frac{m_3 - m_2}{m_2 - m_1}$$

The product complies with the particle size grading requirement, for a:

- Soil conditioner if not more than 20% is retained on the sieve;
- Fine mulch if more than 20% but less than 70% is retained on the sieve; and
- Mulch if equal to or more than 70% is retained on the sieve (AS 4454, 2003).

Plate 13. Equipment needed for the particle size grading test.

Plate 14. Sieving of the sample through the 16 mm sieve (left) and weighing of the sieved fraction on the small balance (right).

Notes:

Important references

- Miller, F.C. (1993). Composting as a process based on the control of ecologically selective factors. *In:* Soil Microbial Ecology: Applications in Agricultural and Environmental Management. F. Blaine Metting Jr (Ed.). New York, USA. Marcel Dekker Publishing. pp. 515-544.
- Recycled Organics Unit (2002). Guide to Developing a Process Control System for a Composting Facility. Second Edition. Recycled Organics Unit, internet publication: www.recycledorganics.com
- Standards Australia (2003). AS 4454–Composts, soil conditioners and mulches. Standards Australia, Homebush, NSW.

Acknowledgement

The authors would like to extend a special thankyou to members of the peer review committee for critically evaluating this document: Dr Trevor Gibson, NSW Agriculture; Dr Kevin Wilkinson, Agriculture Victoria; Mr Darren Bragg, Resource NSW; Mr Garry Kimble, Quality Assurance Services; Dr Martin Line, University of Tasmania; Mr Chris Rochfort, EC Sustainable Environment Consultants and Dr Pam Pittaway, University of Southern Queensland.

Produced by:

Recycled Organics Unit
PO Box 6267
The University of New South Wales
Sydney Australia 1466

Online contact details:

ROU	Angus Campbell
Internet	www.recycledorganics.com