Information Sheet No. 3-3

On-site Field Testing and Monitoring for Quality

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Why is on-site field testing and monitoring important?

On-site field testing procedures are employed at a composting facility to maintain *process control* and to generate products of consistent quality.

Testing and monitoring is a core component of a *Quality Management System (QMS)*, required to ensure that the systems in an organisation are performing effectively.

Process control is defined as the 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 (Recycled Organics Unit, 2002).

Products that vary in quality over time may result in customer dissatisfaction and loss of business. This can occur when manufacturing systems are not regularly checked and when products are not tested against pre-determined quality criteria.

To avoid releasing non-conforming products containing recycled organics into the market place — that is, product which does not conform to specification — testing and monitoring procedures need to be employed at all stages of production.

There are two categories of testing that can be performed on-site.

Rapid, on-site testing can be done in the field (e.g. at the composting pile) with lightweight and portable scientific equipment.

Field tests can be performed quickly, allowing the immediate identification of problems. This allows problems to be quickly rectified, thus minimising impacts on final product quality.

The second type of on-site testing possible at a composting facility is laboratory testing. This involves the analysis of samples in a dedicated room, usually with non-portable and more accurate equipment than that employed for field testing.

On-site laboratory tests that can be used to maintain process control and product quality at a composting facility are discussed in Information Sheet No. 3-4.

This Information Sheet reviews easy, inexpensive field tests that can be used to from the basis of a testing program at a composting facility.

Easy-to-do field tests

Field testing should be performed at all stages of the production cycle, though the stages will vary depending on types of *feedstocks* processed, how they are managed on-site, and what type of products are manufactured.

Please note that tests described in this Information Sheet are targeted towards composting operations.

Tests performed in the field can also play an important role in environmental management. For example, monitoring of oxygen content within a *turned pile* can indicate when odour formation is likely to occur. Interventions, such as aeration or turning may be needed so that anaerobic or low oxygen conditions do not form, thereby minimising the potential for odour production and impacts on air quality.

Tests used do not necessarily have to conform to those outlined in an Australian Standard or other relevant standard.

What is important is that tests are employed regularly and consistently to maintain product quality, most effectively achieved through the application of a well documented QMS.

It is important to note that not all tests can be done in the field or in an on-site laboratory. When a new type of feedstock is accepted at a composting facility, for example, nutrient content may have to be analysed by an off-site laboratory to allow a compost recipe to be formulated.

Field tests described here are quick and easy to perform. Tests are described for:

- temperature;
- moisture content;
- pH;
- maturity; and
- oxygen status.

Suppliers and approximate prices for scientific equipment recommended for each of these field tests is shown in Figure 1.

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

Feedstock
Organic materials used for composting or related biological treatment systems. Different feedstocks have different nutrient concentrations, moisture, structure and contamination levels (physical, chemical and biological).

Turned Pile
System of composting involving the periodic turning of piles of organic matter with mechanical equipment (e.g. front-end loaders or specialised windrow turners) between 1.5 and 3 m in height. Turning assists in: aeration and oxygen re-supply; eliminating odours; reducing consolidation, and moisture and nutrient re-distribution.

Pasteurisation
The process whereby organic materials are treated to kill plant and animal pathogens and weed propagules.

In-vessel
System of composting involving the use of an enclosed chamber or vessel in which (in most cases) the composting process is controlled by regulating the rate of mechanical aeration. Aeration assists in heat removal, temperature control and oxygenation of the mass. Aeration is provided to the chamber by a blower fan which can work in a positive (blowing) and/or negative (sucking) mode. Rate of aeration can be controlled with temperature, oxygen or carbon dioxide feedback signals.

Figure 1. Equipment suppliers and approximate prices

Temperature meters
- Bimetal windrow thermometer: analogue type, stem length 91 to 183 cm, stainless steel probe, crystal face, hermetically sealed. REOTEMP Instrument Corporation, USA. Cost $223 to $554.
- Digital hand held composting thermometer: water resistant digital meter, LCD display, 91 to 183 cm stainless steel compost probe. REOTEMP Instrument Corporation HI9063, USA. Cost from $944, depending on probe length (see Plate 4).

pH kits
- pH test kit: pocket sized with enough tablets to perform 50 tests, and calibration chart, pH range 4-8. Palintest SL150, available from Crown Scientific, NSW. Cost $115 (see Plate 11).

Maturity kits
- Compost maturity test kit: measures carbon dioxide and ammonia concentrations based on gel colorimetric analysis. Kit for 6 analyses, manufactured by Solvita, available through Biotec Pacific, Victoria. Cost $198 (see Plate 15).

Oxygen meters
- Combined oxygen and temperature meter: portable, stainless steel probe, 9V battery, galvanic cell type oxygen detector, LCD display, resolution 1%, accuracy ± 1%. Manufactured by Demista, USA and available through Enviromulch Pty Ltd, VIC. Cost about $2376 (see Plate 20).

Field testing safety tips

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

- Gloves: These should be worn at all times to prevent injury from sharp objects (e.g. glass and metal in contaminated feedstocks).
- 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 hot water afterwards.

Sampling

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

The sample (or sampling points) should reflect the overall characteristics of the material being tested.

Testing performed on a sample that is not representative of the bulk material will produce unreliable results.

Collect a number of samples from different, representative locations in a pile and/or from several piles to ensure that a representative sample is obtained. Mix these samples together well and then draw sub-samples to be tested from the mixture.

Avoid taking a disproportionate number of samples from the centre, edges, and outer surface, which are likely to have different qualities from the bulk of the material in the pile.

A recommended sampling procedure for testing has been reported in AS 4419 (2002) for Soils for Landscaping and Garden Use. This method was developed for sampling a batch of product ready for sale, though it can be easily adapted for use as in-process sampling method.

The method shown below is appropriate for field testing procedures that require a sample of material for analysis.

1. From each batch of material (e.g. a windrow, pile or from a vessel) to be tested, collect 20 random samples at various depths, each having a volume of not less than 1 L (Plate 1).
2. Blend these samples to prepare a composite sample of not less than 20 L (Plate 2).
3. A sub-sample should be taken which is convenient to work with and suited to the testing equipment and containers. Sub-

Plate 1. Random sampling of finished compost from 20 different points in the pile.

Plate 2. Blending of random samples to form a 20 L sample of homogenous, finished compost representative of the bulk material.

sampling can be done by the 'coning and quartering method'. Form the combined sample into a conical shape on a clean surface;

4. Quarter and mix the sample in successive steps until the sample volume is reduce to a suitable size Plate 3).

Usually 6-10 L of sample is required for a full range of tests.

In the time that elapses between collecting and testing, it is possible for samples to lose moisture and undergo other changes. Therefore, samples should be collected shortly before testing.

If samples must be collected some time in advance, they should be refrigerated (~2°C) in a sealed plastic container or bag (NRAES, 1992).

If samples are to be analysed by an off-site laboratory, seal the sample in a plastic bag and dispatch the same day of sampling.

Note that if the sample is to be analysed for organic contaminants, a 1 L sample needs to be placed into a glass jar and sent to the laboratory as well. This is because the organic contaminants can react with plastic polymers in the bag.

A convenient way of posting the packaged samples is in a polystyrene box.

Plate 3. Sub-sampling of the combined sample by coning and quartering. The combined sample is formed into a cone, and divided into quarters.

Temperature

Temperature monitoring is an important component of a good process control system at a composting facility.

The temperature of a composting system influences microbial growth and rates of decomposition.

In composting systems that do not have automatic temperature control (e.g. through forced or induced aeration), maintenance of optimum temperatures (55-60°C) are usually achieved through mechanical turning (Miller, 1993).

Temperature monitoring can indicate:

- how well the process is performing — poor feedstock recipes fail to heat up;
- when (or if) turning or aeration is required; and
- when the material has been *pasteurised* — meaning that weed propagules and pathogenic microorganisms have been destroyed by heat (55°C for three consecutive days) (Standards Australia AS 4454, 2002).

Materials

- Hand-held temperature meter with a probe at least 50 cm long. The device can be analogue or digital (Plate 4).

Method

Temperature readings are taken in the hottest region of a system. In a windrow, that is the centre. To obtain an estimate of temperature in the core of a windrow, walk along the length and insert the probe, perhaps every few metres depending on windrow length (Plate 5).

Note the ends of a windrow will be cooler, due to higher surface area available for heat loss. Sum the temperature readings and divide by the number of readings taken. This will be the average core windrow temperature.

If all the mass present in a windrow, *in-vessel* or alternative system reaches temperature in excess of 55°C for 3 consecutive days, effective pasteurisation of the material has occurred (Standards Australia AS 4454, 2002).

A minimum of three turns (for turned pile systems) should be performed during this period to ensure the entire mass achieves a temperature above 55°C.

If material within the windrow or other system does not heat up, check moisture content (next section) and the recipe to ensure that adequate nitrogen was provided at the start of composting.

If the compost temperature exceeds 60°C, mechanical turning or some other form of aeration should be performed to remove excess heat.

Plate 4. Digital hand held thermometer and stainless steel probe manufactured by REOTEMP, USA (see Figure 1 for details).

Plate 5. Measurement and recording of temperature at the centre of a static pile.

Moisture content

Moisture content is the portion of water 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).

Accurate moisture content measurements can be made in an on-site laboratory (Information Sheet No. 3-4), but this is difficult in the field.

The method reported here is based on the 'squeeze test' (Federal Compost Quality Assurance Organisation, 1994). This test provides a rough estimate of moisture content, but cannot be used to estimate the volume of water required to increase moisture content of a material. Neither can it be used to estimate the moisture content of a material with large particle sizes (>10 mm).

The squeeze test just gives an indication as to whether a material may be 'too dry' or 'too wet' for composting.

Materials

- ~1 L of fresh test sample.

Method

1. Press a sub-sample into the flat of hand (Plate 6).
2. Close hand around the sample and squeeze firmly (Plate 7).
3. Open fist and evaluate structure of sample.

If the sample is sufficiently moist for composting, it should crumble with light pressure (Plate 8).

If the sample deforms, and does not fall apart when pressure is applied, or if water is released, it is too wet (Plate 9).

If the sample crumbles without further action when the fist is opened, the sample is too dry for composting (Plate 10).

If the squeeze test indicates water is required to increase the moisture content of the material, it is suggested that moisture content be measured by the moisture content test reported in Information Sheet No. 3-4.

Plates 6 (left) and 7 (right). A small handful of sample is needed to do the 'squeeze-test' for moisture (left). Squeezing of sample (right).

Plates 8 (left) and 9 (right). Sample at a suitable moisture content for composting (left). The sample does not fall apart when the hand is opened, and breaks apart with light pressure. When the sample is at a correct moisture content for composting, no water is released between the fingers. Sample too wet for composting (right). Water is released between fingers.

Plate 10. Sample is too dry for composting as it crumbles once the fist is opened.

pH

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

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.

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.

The test described here uses a soil pH test kit. It is easy to use, reliable and results can be generated in about 2 to 3 minutes.

Materials

- Colorimetric field pH test kit (see Figure 1 for details and Plate 11 for a picture of the Palintest™ Kit used).
- Bottle of distilled water.

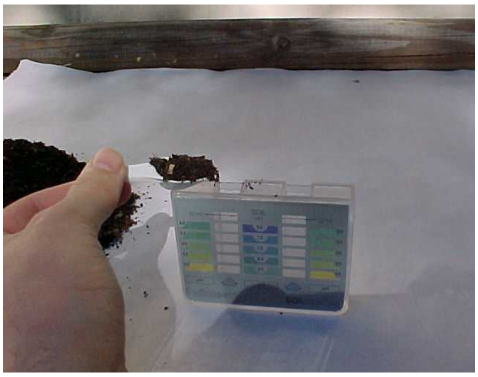
Method

1. With the small scoop, transfer a 2 mL sample into each of the reaction wells. It is wise to duplicate the test just in case a non-representative sample is used (Plate 12).
2. Add distilled water until the 10 mL maximum fill line is reached. Cap the reaction vessel with the rubber stopper, shake, and add more distilled water if the 10 mL line is not reached (Plate 13).
3. Add one reaction tablet per well. Shake the reaction vessel end-over-end for one minute.
4. Allow the solids to settle for a minute or two and compare the colour of the solution to the colour pH scale on the front of the reaction vessel (Plate 14).

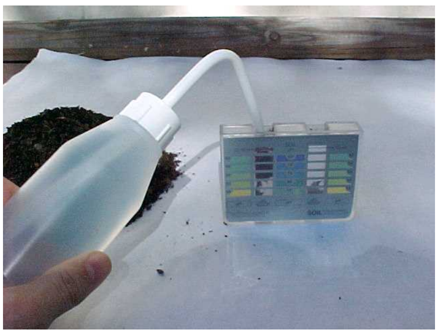
In general, organics most suited to composting have a pH between 6 and 8, and final products should have a pH which conforms to user requirements or a relevant product standard (e.g. 6.5-7.0).

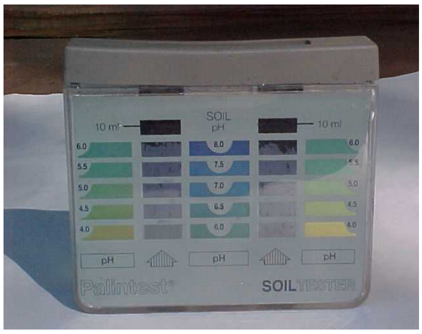
If feedstocks have a pH of less than 5, lime (calcium carbonate), hydrated lime (calcium hydroxide) or quicklime (calcium oxide) may need to be added to neutralise acidity present. If pH is greater than 9, an acidifying agent may need to be added to the material (e.g. elemental sulfur).

Plates 11 (left) and 12 (right). Test kit used for testing pH (see Figure 1 for details) (left). This pH test kit comes with a reaction vessel which can analyse two samples at a time, and a surface printed colour chart for reading the pH value, colorimetric reaction tablets (in foil), a 2 mL sample scoop and a mixing spatula. Distilled water and bottle need to be purchased separately. All hardware stores stock distilled water and bottles (left). Add samples to the two test wells (right). It is a good idea to assess pH of the one bulk sample twice to ensure consistent results are obtained.



Plates 13 (left) and 14 (right). Add distilled water until the 10 mL line is reached (left). Determine the pH of the sample by comparing the colour of the solution to the standard colour chart printed on the face of the reaction vessel (right).





Maturity

Composts that are not fully decomposed, in some cases, can damage plants when incorporated into soil, or when applied in excess as a mulch.

Immature products continue to undergo decomposition, resulting in oxygen consumption and temporary nutrient immobilisation in soil.

To ensure that composted products are fully decomposed prior to sale, a maturity test should be performed on a batch.

Such tests, however, are not appropriate for pasteurised products as they are sold as 'immature products'. Pasteurised products have limited applications, being restricted for use largely as surface mulches.

The test reported here is based on the Solvita™ Compost Maturity Test by Woods End Research Laboratory® Inc., USA. The test is based on the use of gel-colorimetric analysis.

It is a rapid test — a result can be obtained in four hours if the sample is at an appropriate moisture content.

Laboratory-based maturity tests involving the germination of seeds can take up to 5 days to generate a result. As a result, the Solvita Compost Maturity Test is being widely used in the USA as a rapid on-site maturity test.

The test uses a gel that is sensitive to carbon dioxide gas evolved by immature composts. Maturity is determined by comparison against a standard colour chart.

Materials

- One Solvita™ Compost Maturity test kit containing a gel stick, buffer pack and sample jar with a colour chart (see Plate 15 and Figure 1 for details).
- One 2 L plastic container.
- One paddle-pop stick.
- ~0.5 L fresh test sample.

Method

1. Place 0.5 L of the sample into a 2 L plastic container and remove large particles (>10 mm) by hand.
2. Take a fist-full of the sample and squeeze tightly. The sample should wet the hand but not yield free water. Water should be added if too dry. If the sample is too wet, spread on paper towelling and let it dry out overnight at room temperature.
3. Empty one 'Solvita Buffer' pack into the plastic container and blend well by stirring with a paddle pop stick (Plate 16).
4. Place some of the sample into the jar until the fill line is reached. Lightly tap on bench to consolidate sample. Top up with more sample if needed (Plate 17).
5. If the sample needed to be re-moistened, let the jar stand with the lid placed loosely on the jar for 16-24 hours. For samples not requiring re-moistening, proceed to step 6.
6. Open the 'Solvita Test' foil packet (containing the gel stick) and be careful not to touch the contents. Do not allow the compost to touch the gel surface of the stick. Insert the pointed end of the gel stick into the sample so that it can be seen through the side of the jar. To do this, push the tip of the gel stick to the bottom of the jar. Do not use the gel stick if the gel is dried out or if the colour is not #8 on the chart (Plate 18).
7. Screw the lid tight and allow to stand at room temperature (20-25°C) in the shade for four hours.

Read the Solvita colour four hours after the test is started. To read the colour, observe the gel stick through the viewing side of the jar with the lid on. If condensation obscures the view, wipe it off with a tissue then replace lid. To assess sample maturity, compare gel colour to the colour chart (Plate 19).

The test can be used to identify whether a batch of mature compost, or products containing mature compost are ready for sale.

Note that some products may be 'immature', though they may qualify as a 'pasteurised' product. Determination of whether a product is 'pasteurised' is not possible with this test.

In this case, temperature monitoring is required to prove that pasteurising temperatures were achieved for a sufficient period of time so that the product can be referred to as 'pasteurised'.

For this reason, the Solvita Compost Maturity Test should be used for products that are sold as mature composted products.

Plates 15 (left) and 16 (right). The Solvita Compost Maturity test kit (left). Add buffer to the sample and mix thoroughly (right).

Plates 17 (left), 18 (centre) and 19 (right). Place some of the sample into the jar until the fill line is reached (left). Insert the gel stick into the sample. Make sure the gel surface does not come into contact with the sample (centre). Determine maturity of sample by comparing it to the colour chart on side of jar after a period of 4 hours. In this case, the sample of compost can be considered to be immature, still requiring turning and aeration (right).

Oxygen status

Oxygen (O_2) in a composting system has a marked affect on the rate of decomposition and odour formation.

During the decomposition process, microorganisms consume oxygen present between the voids of composting particles. The rate of decomposition of organic materials is fastest when high levels of oxygen are present. Microorganisms require oxygen to oxidise or break down the organic fraction into simpler compounds.

If low oxygen conditions develop, significant quantities of odour can be generated by microorganisms — in the form of ammonia (NH_3, a pungent smelling odour), hydrogen sulfide (H_2S, rotten egg smelling odour) and dimethyl disulfide (CH_3SSCH_3, a foul smelling odour) (Miller and Macauley, 1988).

Maintaining an aerobic (high O_2) composting environment is the key to minimising odours and maximising the rate of decomposition. Oxygen monitoring can be useful when potentially odorous feedstocks are processed (e.g. food organics) in turned piles or in-vessel composting systems.

Oxygen monitoring with a galvanic cell type portable meter can determine when turning or aeration is required.

To minimise odour generation and to maximise rate of composting, the concentration of O_2 (on a volumetric basis) should be kept above 12% (Standards Australia AS 4454, 2002).

In normal outdoor air, the concentration of O_2 is ~20.9%.

Materials

- One portable O_2 meter with a probe at least 50 cm long (see Plate 20 and Figure 1 for outlets).

Method

1. Turn the meter on and check battery status. Depending on the type of meter, a warm up period of up to 5 minutes may be required.

2. If needed, calibrate instrument by aspirating the cell (squeezing and releasing the rubber bulb to draw fresh air into the unit). Check display to make sure it is reading 21% (most meters round the result to the nearest whole number). Adjust calibration screw if required.

3. Walk along the length of the windrow (or similar composting system) and insert probe, perhaps every few meters depending on length or size of windrow. The probe should be inserted into the centre of the composting mass where O_2 deficiencies are more common (Plate 21).

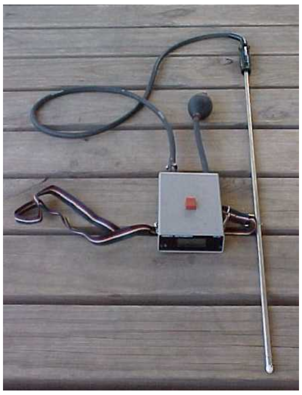
4. Aspirate bulb on the meter four to six times until the reading becomes steady (Plate 21).

5. Record reading.

6. Note the ends of a windrow will have a higher O_2 concentration, due to higher surface area available for gas exchange. Sum the O_2 readings and divide by the number of readings taken. This will be the average O_2 concentration.

Oxygen concentration should preferably be greater than 10% for optimising process efficiency. Facility managers can specify a threshold concentration that triggers the timing of aeration. It is suggested here that if the concentration of O_2 is less than 12% in an actively composting mass, it is time to schedule turning or otherwise aerating the composting mass to prevent odour formation and to maximise the rate of decomposition.

Plates 20 (left) and 21 (right). A combined O_2 and temperature meter with a stainless steel probe manufactured by Demista (left). Sampling of gas in the centre of a static pile (right). The bulb is being aspirated to withdraw air from the compost pile into the O_2 sensor located in the meter.



Notes:

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