

## PRODUCT EVALUATION

# FIELD TEST FOR COMPOST MATURITY

**I**N THE fall of 1995, over 80 samples of composted materials were taken from more than 40 compost operations throughout Maine to evaluate a new test kit marketed as giving an accurate indication of the level of compost maturity in four hours. The site visits and testing were carried out by the Maine Compost Team, who gained first hand knowledge about the compost operations, the ingredients included and site management.

In recent years, compost maturity has been recognized as one of the key characteristics for determining a product's usefulness for various purposes. Because of this, a test that promises to give a reading of the level of maturity within four hours could potentially be very useful for knowing when to market a compost and for what purposes. The kit also can be used as a process control tool. Evaluating it for that purpose would require a different type of study. The team has deliberately limited their assessment to the use of the kit for determining the maturity and use of compost products.

The rapid test, developed by the Woods End Research Laboratory, measures the CO<sub>2</sub> generated by a given quantity of compost material, working on the principle that more active compost will generate more CO<sub>2</sub> in a fixed time period than a more mature compost. The Solvita kit consists of a small jar with a color scale on the label, a packet of buffer and a packet containing a small plastic 'paddle' that has a CO<sub>2</sub> sensitive gel surface on one side. The gel will change color according to the amount of CO<sub>2</sub> in the atmosphere within the jar.

Eight different colors (and maturity levels) are identified in the literature with the kit. Comparison between the paddle color and the color scale allows the tester to determine the current level of maturity of the material and consequently best uses for the material. Color numbers 1 and 2 indicate a "raw" compost; 3, 4, 5, and 6 are "active" composts; and 7 and 8 are "finished" compost. A definition is given for each number, e.g. 1 is fresh raw compost typical of new mixes; 3 is an active compost with a high respiration rate; 5 is moving past the active phase of decomposition, is ready for curing and has a reduced need for intensive management; and 7 is well matured, aged compost and ready for most uses.

For this study, the team considers maturity to be a measure of a compost's readiness for use based on a number of factors, e.g. low levels of ammonia and volatile organic acids and a pH near neutral. Maturity generally increases with age in a true composting system. One of the measures of maturity is stability — the level of biological activity present in the material. Normally, this activity increases initially in the composting process until it peaks between one and three weeks and then gradually declines as the more readily decomposed materials are exhausted. Stability, however, may be measured in materials that are not mature if something has interrupted the natural biological activity such as excessive heating or drying. In

*A rapid compost maturity test was evaluated by the Maine Compost Team at more than 40 sites in the state. To determine the accuracy, compost from the same samples also were compared using self-heating and respirometry tests in the lab.*

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these situations, the material will revert to an unstable condition if the correct moisture, temperature and aeration are provided. Truly mature material will remain stable even if remoistened and aerated.

## STUDY METHODS AND RESULTS

The purposes of the study were to test the ease of use of the Solvita kit; assess the reproducibility of the results obtained; determine its accuracy when compared to other approaches for testing maturity; identify any limitations to its use or conditions under which it should not be used; and collect other data about the compost operations for further evaluation of maturity readings.

When selecting facilities, care was taken to make sure that all the major feedstocks being composted in Maine were included. At each operation, a five quart sample of one or more compost product(s) was collected. (To ensure an independent analysis, the Compost Team made all the site visits and collected all the samples.) Each sample was split into a four quart portion to send to Woods End and a one quart portion to be tested by the team using the Solvita test. Woods End tested the samples using the Dewar's flask self-heating method, CO<sub>2</sub> respiration and the Solvita test. The Compost Team prepared samples and performed the Solvita maturity tests according to the instructions in the kit. Samples delivered to Woods End were identified only by a number and the date collected.

The Compost Team's results were developed and evaluated independently from Woods End and likewise, the analyses performed by Woods End were done without access to the team's Solvita test results. Each group developed its own discussion of the study results and drew its own conclusions about the usefulness and limitations of the test. At the completion of all the testing, the two sets of data were compared and evaluated by both parties.

**Ease of Use:** The Compost Team found that the kit was fairly easy to use. The directions were, in general, clear but some changes would help improve them. In particular, it would be helpful if the directions distinguished the steps for different compost conditions after the moisture of the sample has been checked. At that point, there are

three possible sets of steps that must be followed — one for samples that are too dry, another if they are too wet and a third if samples are ready to test. A flow chart outlining the steps for each of these situations would help clarify the process.

Sample preparation was by far the most time consuming part of the process. It only took about five minutes to prepare one sample for testing, but if a number of tests are being conducted, this process can require up to an hour. Adequate counter space also is necessary. Sample preparation can be messy and at times, depending on the samples, result in the release of odors.

Once the sample is ready for testing, a maturity reading can be obtained in four hours. If the samples are too wet or too dry, however, they must either be dried overnight or moistened and allowed to sit at room temperature for 24 hours. The buffer is then added, a subsample is placed in the test jar and the color paddle is inserted. The color is read four hours after the paddle is inserted.

In the study done by the team, nearly half of the samples had to be either moistened or dried before they were suitable for testing. (The kit's instructions suggest that proper moisture can be judged by using the hand squeeze test.) For many samples, this meant test results could not be obtained the same day the sample was taken — however this is faster than getting results from a laboratory. When the results were ready, reading the color scale was found to be reasonably easy to do, even for users with red/green color blindness.

**Reproducibility of Results:** The team conducted a number of trials to determine if results for a sample could be reproduced. Several people, including team members, were asked to independently match several color paddles to the color scale. In general, they all selected the same color or had to choose between the same two. In cases where a sample was divided into two subsamples after it had been prepared for testing and two test jars and two paddles were used, identical results were obtained.

To test the reliability and reproducibility of the test results, the team purchased six commercially available bagged soil amendment products. Each member of the team took a one pint sample of each of the six products and independently performed the Solvita test. Test results were tabulated and compared based on their variances.

Despite differences in handling and preparation procedures used by the different team members, there was consistency in the results. Variances for four of the six samples were very low, indicating a high degree of agreement in the results. The two samples with high variances were not typical of true compost products. One was a heat dried and pelletized biosolids product that tested mature after a 24 hour wetting period, then tested immature two days later. The other was an extremely heterogeneous material that contained a mixture of soil, dried manure and bedding. Different parts of the bag had varying amounts of each of these components.

When the small (one pint) samples were taken from the larger bag, it was possible to see that the samples were visually very different. This variability was noted at the time of the sampling. Not surprisingly, the different samples demonstrated varying levels of maturity.

In summary, there was a high degree of consistency between the readings of different team members. It is extremely important when sampling to get a homogeneous and representative sample of the material so that the test results can be reproduced.

Another test for consistency was the comparison between the Solvita results obtained by the Compost Team and the results produced by Woods End Lab. Figure 1 illustrates the high degree of correlation. The maturity readings obtained by the lab were consistently higher than those produced by the team — on average, one Solvita unit higher. The difference between the two sets of readings can be explained by some differences in sample handling and preparation. For example, the lab held samples in a refrigerator until they were to be prepared for testing, while the team generally allowed the samples to warm up to room temperature (often for 24 hours) prior to preparing them for the test; and for samples that were too wet, the lab used a fan dry system to speed the drying process, whereas the team allowed the wet materials to air dry overnight, spread out on a plastic sheet. In both cases, the method used by the lab would be expected to reduce the amount of biological activity in a sample when compared to the methods used by the team, thus giving a higher maturity reading. The team felt that their approach to sample preparation better reflected the process that would be used by composters themselves and gave a better indication of the level of maturity actually achieved by a material.

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## MIX IT



The Reel Auggie® Sludge and Organic Compost Mixer, for blending sludge and amendments, sludge stabilization, yard waste, food waste, and solid waste composting. Available in truck, electric, tractor, or diesel drives.

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The kit's directions need to be followed as closely as possible to insure accurate and reproducible results. It is particularly important to read the color at the right time.

**Accuracy of the Test:** The team tried to determine the accuracy of the test in two ways — by comparing the results with those obtained from other maturity measures (the Dewars flask test and carbon loss); and a comparison of the results with a subjective assessment of materials based on their ages, ingredients, odors, management and homogeneity of the mix.

The relationship between the Solvita readings and the Dewars temperature changes was compared for 72 samples. The variation in self-heating is greatest for readings in the middle of the Solvita scale — levels 4 and 5 range from zero to 50°C, while readings at the upper end of the scale are very closely clustered. Despite the considerable variation in the individual readings, there is a very significant relationship between the Dewars temperature reading and the Solvita test results. In general, the higher the temperature rise in the Dewars tests, the lower the readings from the Solvita test.

When the Solvita readings are compared to the percent carbon loss per day, an even tighter relationship is evident. As would be expected, the Solvita readings increased as the amount of carbon loss per day dropped. The relationship is particularly strong on both ends of the scale, i.e. for readings of 6 or above and for readings 3 and below. For readings in the 4 and 5 range, there is a much wider variation in the carbon loss numbers.

The comparison between the Solvita readings and a subjective evaluation of maturity showed general agreement between the expected results and the actual results with a few notable exceptions. A number of samples that were highly odorous and apparently not mature had much higher readings than would be expected. It was suggested that the odor causing compounds may be interfering with the production of CO<sub>2</sub> or with the gel's ability to react with the CO<sub>2</sub> being produced. Ammonia, for example, is known to inhibit respiration, causing a reduction in the CO<sub>2</sub>

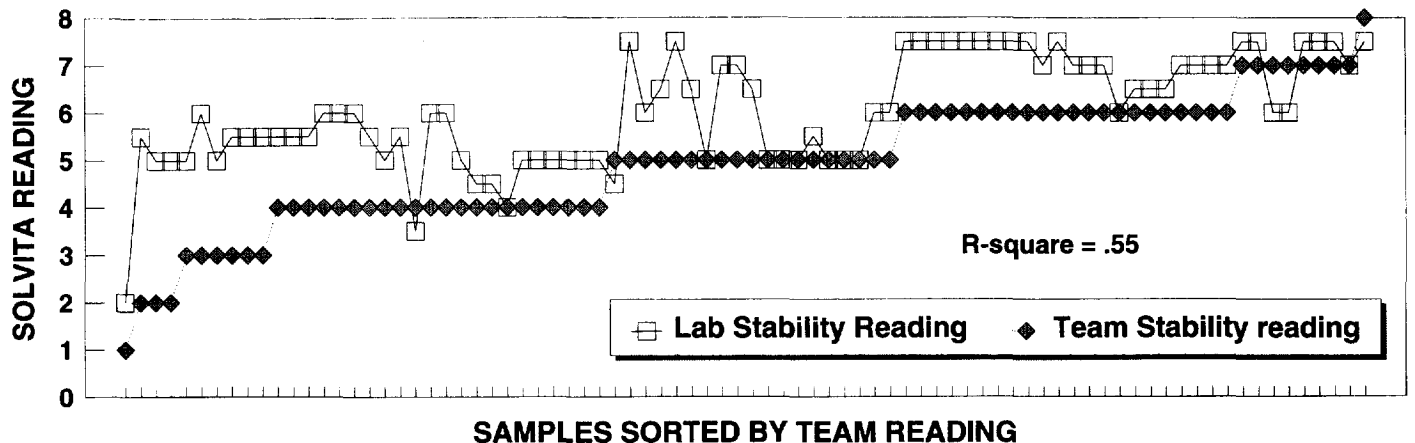
produced. In addition, a few very young samples displayed higher measures than would be expected. It was hypothesized that for these young samples, the bacterial population may not have had time to establish itself sufficiently to raise the level of activity to its highest level. This fits the model of a system in which activity rises initially, reaches a peak and then gradually tapers off.

#### TEST LIMITATIONS

The bulk of the samples tested fell very close to what the team expected the stability level would be for that stage of the composting process, demonstrating that the Solvita test works quite well for normally composted materials and especially for those nearing maturity. There are, however, situations in which the test can give questionable results. The first and perhaps most obvious is using the test on a product that is either too wet or too dry. Even though the instruction sheet directs the user to gauge the moisture and correct it prior to conducting the test, this may not produce accurate results if the material being analyzed has been subjected to excessive drying or heat stress. The results of the substudy with the heat dried biosolids demonstrates this point. Even after moistening the material and allowing it to sit for 24 hours, the Solvita test indicated that it was highly mature (registering a 7 on the 8 point scale). The same material tested after another 24 hours, however, registered a 1, showing that it was in fact extremely immature. This highlights the need to allow additional time for dry or heat stressed materials to recover before applying the test. For example, an operator who is aware of a heat stressed situation (e.g. a long period without rain which causes the compost to dry out and temperatures drop) may want to rewet the material and wait 48 hours to do the maturity test. If the test is done after the 24 hour period and a high maturity reading is given, the operator may want to wait another 24 hours and retest. If the reading is still high, it is likely the product is mature.

Composting materials that were still highly odorous, even after composting for some

Figure 1. Team versus lab results for Solvita readings



time, also were found to give questionable maturity readings. Several samples of this type were noted during the study. Some of these obviously had been in an anaerobic state for some time and were highly putrescent and immature. Despite this, however, they registered as high as a 5 on the scale. It was not clear whether this was caused by inhibition of the microbial activity, by interference with the chemical reaction of the gel, or some combination of these two effects. The presence of volatile organic acids (VOAs) and ammonia will affect the color response of the gel. The inclusion of the buffer in the process is intended to address these problems, especially with ammonia. The presence of an ammonia smell even after adding the buffer should be taken as a sign that additional buffer may be needed and that additional time may be necessary before performing the test. If the material is highly odorous but does not exhibit an ammonia smell, it should perhaps be screened for VOAs before performing the test (the presence of a non ammonia odor might indicate a problem with the process and/or the initial mix and serve as another indication that the product is not ready to be used). Similarly, a pH test prior to the Solvita testing may point out a problem that needs adjustment, so that a more accurate result can be obtained.

A compost that has a high C:N ratio, e.g. many leaf composts and paper sludge composts (C:N of about 60:1), takes a longer time to mature than those with C:N ratios in the range of 20:1 to 30:1. At any point during the middle of the composting process, these types of composts will register fairly high in stability when they are, in fact, far from being mature. Two compost piles that contained only leaves registered a 6 and a 7, even though both consisted primarily of leaves that were not visibly very different from when the piles were built.

In another situation, two samples were tested at a crab and sawdust compost operation. This process generated a mix with a high C:N ratio and a nonhomogeneous mixture. A sample was taken from a pile that was two weeks old and another from a pile that had been curing for a year. The two week old pile gave a maturity reading of 6 while the year old product registered a 4. This implied that the year old product was significantly less mature than a new mixture of the same materials. Examination of the new pile, however, showed that much of it was sawdust with large pieces of crab shell scattered throughout. In such a setting, it is virtually impossible to take a small sample that will adequately characterize a pile.

Another situation where the test gives a false reading of maturity is when it is done on a sample of newly mixed materials. Solvita actually measures the amount of respiration occurring in the material. Since the microbial population may not have had the opportunity to become established in a new mixture, the respiration may be low, resulting in a higher reading on the scale. A sample of a biosolids compost mix taken from a pile as it came out of the mixer was highly immature,

not having begun the composting process, and yet it registered a 5 on the Solvita scale. Samples taken at later stages in the same process actually gave lower readings despite having composted for two weeks or more.

Use of the test kit in any of these situations would not give an accurate indication of maturity. To make best use of the kit, operators need to understand the composting process well enough to determine when it is logical to conduct the test. The end uses for the product also factor into that determination.

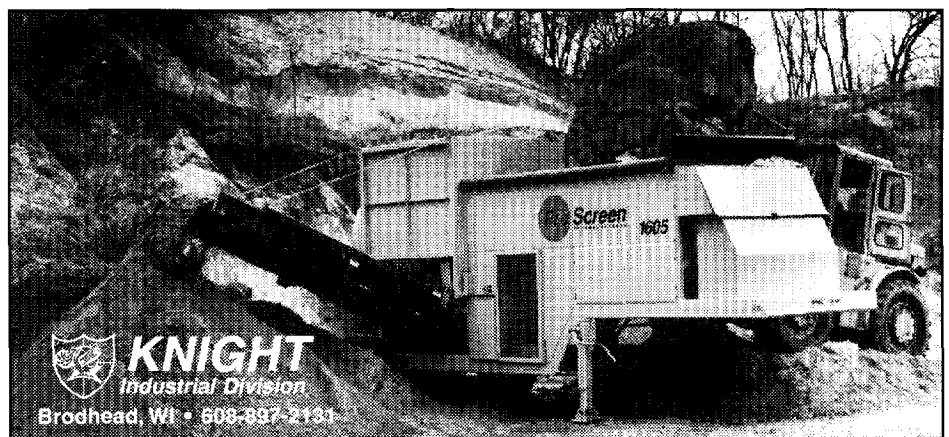
#### CONCLUSIONS

It is apparent from the results obtained in this study, that the test works well for evaluating materials from a true composting process in which the mixture is reasonably homogeneous and the moisture, pH, C:N ratio and aerobic conditions have all been maintained in the optimum range. Composts that significantly deviate from these optimum ranges or are less than two weeks old may appear to be more mature than they are in reality. The Solvita test kit will yield results in four hours once the sample is ready to test. For nearly half of the samples, this meant waiting 24 hours. For heat stressed or excessively dried materials, at least 48 hours are needed after remoistening. In general, the team concluded that in terms of assessing the maturity level of a product and its potential uses, the test is a useful tool as long as the limitations are kept in mind. ■

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Materials that were still highly odorous, even after composting for some time, were found to give questionable maturity readings. It was not clear whether this was caused by inhibition of the microbial activity, by interference with the chemical reaction of the gel, or some combination of these two effects.

## SCREEN IT



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