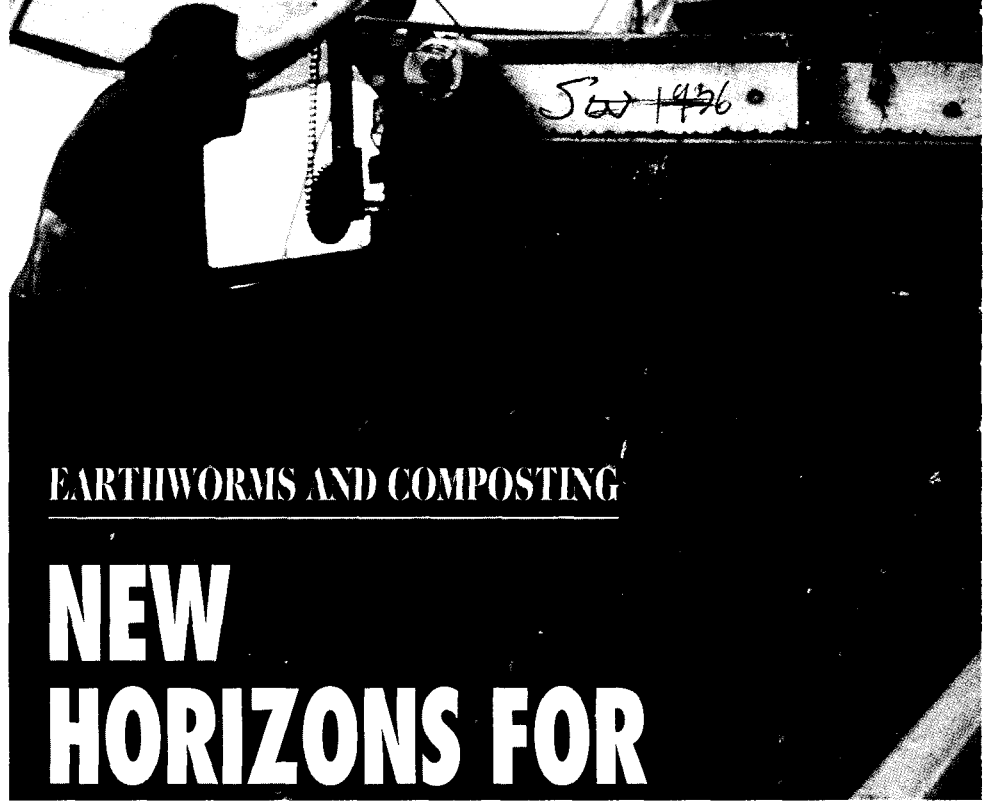


EARTHWORMS AND COMPOSTING

NEW HORIZONS FOR COMMERCIAL VERMICULTURE

Photo courtesy of Oregon Soil

Technologies based on earthworms offer effective methods to compost larger portions of organics in the residential and commercial waste streams.

David Riggle and Hannah Holmes

SEVERAL companies in the United States and Canada have seriously begun sampling institutional and municipal organics as feedstocks for earthworms. The techniques and terminology differ somewhat from place to place, but in Florida, California, Ontario and Oregon, large-scale vermicomposting or vermiculture projects are in progress. This represents a resurgence for an industry that has experienced its share of ups and downs. There are stories of municipalities investing in worms to convert problematic organic wastes to topsoil, only to find that the worms had been killed by a toxic contaminant or had all moved overnight to other, more palatable, pastures. In the 1970s, a pyramid scheme of fish bait franchises quickly saturated the market in California and ultimately collapsed, leaving growers with more worms on their hands than they knew what to do with.

"Actually, this was probably the beginning of large-scale vermicomposting," says Clive Edwards, a professor of entomology at Ohio State University who recently organized an international symposium on earthworm ecology (see accompanying article). "People were stuck with all these worms they couldn't sell but they did have this nice end product and began to wonder who might be interested in it."

As the demand for effective methods of diverting organics from North American landfills grew, earthworms began receiving renewed attention. Consequently, an industry centered around producing worms and utilizing their unquestionable skill at digesting organic material and excreting a top quality soil amendment known as castings, has begun to mature.

INSTITUTIONAL INTEREST

For Original Vermitech Systems, Ltd. (OVS) in Toronto, expanding into larger quantities of worms and organics was a natural outgrowth of earlier work. The company, founded in 1990, initially developed a worm bin for household use called "The Canadian Original Vermicomposter." In 1992, after some success with the small bins, OVS began marketing larger units designed to process between 50 and 100 lbs. of organics per day from restaurants, schools and the like. Since earthworms can consume and excrete their body weight in 24 hours, roughly 50 to 100 lbs. of worms are required for each bin. According to Al Eggen, president of Original Vermitech, five such units currently are installed and operating in Ontario. The company recently signed a contract with the University of Ottawa to install up to ten medium sized bins across its sizeable campus, each initially digesting 50 lbs. per day of food scraps, paper and animal manures.

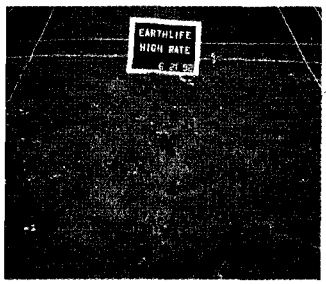
OVS has continued to scale up for still larger facilities. In 1993, a unit with a capacity of up to 600 lbs. of organics per day was installed at the Brockville Psychiatric Hospital in Ontario. "It's the largest vermicomposter in Canada right now," says Lori Halcrow of Ontario's Green Workplace Program, which oversees recycling in Provincially owned institutions (see "Creating the Maximum Green Workplace," *BioCycle*, June, 1994). The system requires preshredding feedstock, and manual loading and unloading, but Eggen equipped it with heat panels and temperature sensors to monitor and maintain a tolerable environment for the worms.

A layer of organic materials is spread on top of the worm digester at Oregon Soil Corporation.

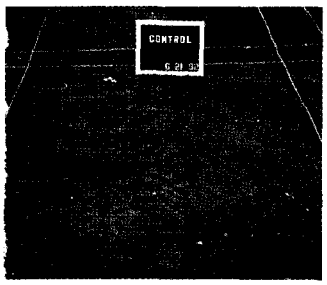
"We've been very happy with it," says Halcrow. "Last winter was very cold, but the worms survived. The staff at Brockville also seems to be pleased. All of their food scraps

LONGEVITY OF SOIL IMPROVEMENTS

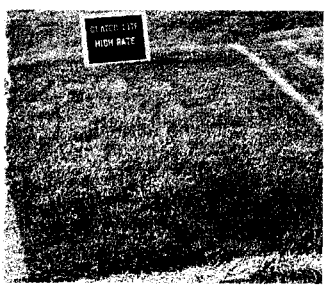
Perhaps the greatest benefits derived from compost additions to soils with high clay content are improvements in soil structure and water infiltration. All compost treatments in this study increased soil organic matter content, reduced bulk density, and increased water infiltration rates when compared with the topsoil treatments and the unamended control.



One of the concerns frequently voiced by grounds managers and golf course superintendents is that the organic matter in composts will break down faster than peat, thereby providing only short-term soil improvement. Although it is true that the organic fraction of most peats is more stable than fresh composts, this does not necessarily mean that the effects of compost additions on soil physical properties are short-term. When applied properly, good quality composts produce dense and actively growing turf stands which generate organic matter in the form of decomposing leaf, stem, and root tissue. The plant-derived organic matter combined with some residual organic matter from compost additions should provide long-term improvements in soil structure. One of the goals of our study is to determine changes in the levels of soil organic matter for the compost treatments over the next several years. Hopefully, we will be able to determine when (or if) additional compost applications are needed.



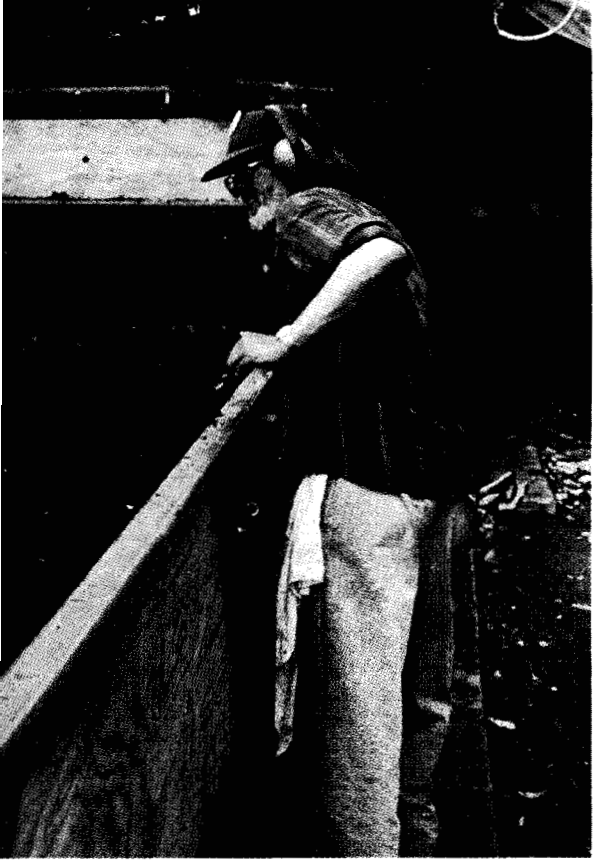
Water infiltration is defined as the rate at which water enters the soil and is one of the best measures of soil physical conditions in the field. All the compost treatments in this test increased water infiltration rates in 1992 and 1993. One treatment, the high rate of BBC, showed a water infiltration rate of 19 inches per hour, whereas the control showed only one inch per hour. To determine the long-term effects of compost additions on soil physical properties, we plan to monitor water infiltration over the next several years.



Although most of the products used in our study significantly improved turf establishment, the quality of established turf, as well as soil chemical and physical properties, much more information is needed on predicting the long-term response of turf and soils to applications of different compost products. Questions that still need to be addressed are: How quickly does the organic portion of certain composts break down, how long will soil improvements last, and will compost additions have lasting effects under high-traffic conditions? More work also is needed on the effects of soluble salts on seedling turf and on the impacts of surface applications of composts on established turf. We are in the process of examining some of these issues and plan to do more testing in the near future. ■

Peter Landschoot and Andy McNitt are in the Department of Agronomy at Penn State Univerisity in University Park.

The plot amended with biosolids compost from the Philadelphia Water Department (top left) showed no additional benefit from a starter fertilizer application on its left half, compared to the control plot (middle left) which received no compost but a similar application of fertilizer. The plot amended with a papermill by-product compost has improved turf color and density — a dramatic difference from the yellow, thin growth in the border areas.



are going into the worm bin, which has lowered their residuals from 33 cubic yards to around eight cubic yards per day. Brockville also has acres of grounds on which to use the vermicompost."

Eggen, who subcontracts the manufacturing for all sizes of the units, says the bulk of his company's sales still come from the smaller, household bins. Nevertheless, he is considering starting a farm to raise more worms in windrows as sales of the larger systems increase.

CONTINUOUS FLOW

Outside of Portland, Oregon, Dan Holcombe's Oregon Soil Corporation has developed a technology to reduce the space requirements for a vermiculture operation. The "continuous flow system" was pioneered in the United Kingdom in the 1970s. Clive Edwards was instrumental in the technology's development, and is working with Holcombe to improve it. It utilizes a raised, 120-foot trough that is 2.5 feet deep and 8 feet wide, with a mesh floor. An adapted manure spreader makes a daily pass over the trough, laying down about three inches of prepared organic materials (roughly six tons per day). As the worms eat up through it, their castings sink down, and are mechanically scraped off the bottom of the screen and collected. Under the protection of a greenhouse like structure, the reactor can handle about 2,500 tons of residuals a year.

In 1993, METRO, the solid waste management agency for Portland, Oregon, sent 1,450 tons of organic material to Holcombe's operation as part of a pilot project, with encouraging results. Reportedly, METRO has expressed interest in additional vermicomposting projects, but thus far has not funded further development.

Currently, Oregon Soil accepts yard trimmings deliveries from local landscapers and picks up food scraps and paper from 15 Fred Meyers one-stop shopping stores around Portland. "We process around five or six tons of food scraps, over two tons of supplementals like yard trimmings or compost, and around half a ton of paper per day," says Holcombe. He points out that it takes 21 days to make earthworm castings using this method.

His operation currently is located on an organic vegetable farm with 65,000 square feet of raised beds. "The farm owner likes to experiment," he says, noting that other vermiculture methods can be utilized in an agricultural setting. When a crop has been harvested, the beds can be filled with worms, paper, yard trimmings and food scraps. The next crop is planted when the worms are finished. In the winter, windrows keep the worms warm enough to function — and again, crops can be planted in the castings.

Holcombe, who has been raising worms since 1988, sees real potential in using them to handle a wide range of biodegradable organics. "I've never seen any mechanical technology do a better job than the earthworms themselves," he says.

TACKLING MUNICIPAL ORGANICS

"It's only in recent years that the notion of harnessing earthworms for commercial waste management has been seriously considered in this country," says Joseph Roberts, president of Resource Conversion Corporation in La Jolla, California, who hopes to develop a series of earthworm projects on a municipal scale. In February, 1993, his company signed a 50/50 joint venture agreement with Residuals Processing, Inc., a subsidiary of Sanifill, a national landfill company. "Sanifill has agreed to install 25 of our vermiconversion systems at their sites over the next decade," says Roberts.

This past July, Resource Conversion and Sanifill opened Canyon Recycling outside of San Diego — a six acre facility currently processing around 100 tons per day of brush, green material, wood from construction and demolition operations and manure from the San Diego Zoo. Not all feedstocks are fed to worms. After grinding and screening, some woody materials are marketed as is. However, leafy greens, wood fines and manures proceed through a blending plant, then "cured" via thermophilic composting to neutralize pathogens. Roberts adds that Canyon Recycling could also use lime stabiliza-

> "I've never seen any mechanical technology do a better job than the earthworms themselves."

At Brockville Psychiatric Hospital in Ontario, food scraps (top), cardboard and milk cartons (bottom) are shredded before being fed to worms.

Photo by Al Eggen

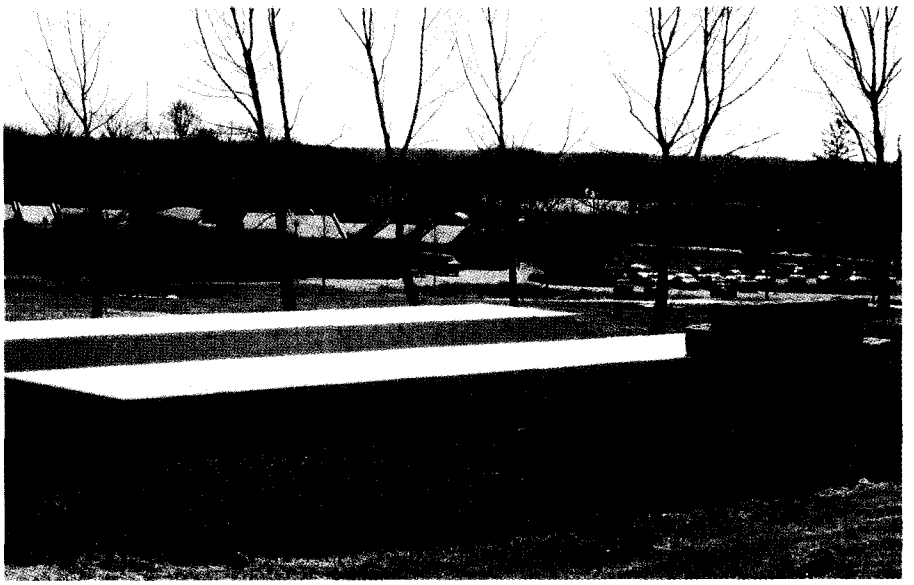


Photo by Al Eggen

Heat panels and temperature sensors maintain a tolerable environment for worms at Brockville Psychiatric Hospital.

WORM RESOURCES

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St. Catharines, Ontario L2M 7W7
Sandra Kandracs
(905) 646-8690

Environmental Earthworm Projects, Inc.
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Orlando, FL 32813
Frank Stevenson
(407) 678-6454

Oregon Soil Corporation
17810 SSW Bunker Oak Rd
Aloha, OR 97006
Dan Holcombe
(503) 629-5933

Original Vermitech Systems, Ltd.
2328 Queen Street East
Toronto, Ontario M4E 1G9
Albert Eggen
(416) 693-1027

Resource Conversion Corp.
7825 Fay Ave., Suite 380
La Jolla, CA 92037
Joseph Roberts
(619) 551-4800

The Worm Concern
1450 Tierra Rejada
Simi Valley, CA 93065
Jay Escover
(805) 496-2872

Worm Digest
Box 544
Eugene, OR 97440-9998
Stephen White
(503) 896-9058

California's draft regulations exclude vermicomposting operations from the notification and permitting that would be required of most larger facilities using thermophilic composting.

tion or other heat processes in the future.

After curing, material is applied to short vermiculture windrows in thin layers. The rows are carefully segregated and checked for biological reactions to new feedstock. "We apply two to four inches of material every other day, continuously," Roberts says. "The rows are compartmentalized to prevent contamination of the entire facility if there should be a problem with any incoming material." Windrows never exceed three feet in height, and earthworms periodically are separated from the castings using a specialized method.

Resource Conversion's windrow system did not develop overnight. In 1989, Roberts purchased a 12 acre facility with a 41,000 square foot building that previously was used to grow mushrooms and started the Soil Master Earthworm Farm near Olympia, Washington to raise earthworms. "From the outset, our aim was to also use the facility for R&D," Roberts says. "We wanted to explore the technology of raising earthworms from a microbiological point of view, test various physical processing systems, and determine the most cost-effective methods."

Subsequently, the company developed a proprietary "Vermiconversion System," which modified traditional vermiculture windrow methods. Variations include a sloped plastic liner beneath the windrows to reclaim water, aeration piping and a micro emitter sprinkler to maintain proper moisture levels.

"With thermophilic composting alone, it's difficult to get an outstanding product in under six months," Roberts says. "With vermiconversion, we can create a marketable end product in one-sixth the time. On the other hand, thermophilic composting does actually achieve PFRP (pathogen reduction) standards and is simpler to manage. We've combined the two and employ thermophilic composting for three to 15 days. When pathogens and weed seed have been neutralized, material is placed in vermiprocessing beds. In 30 days, it's converted to humus. We wanted to be able to move significant quantities of product through quickly to compete for municipal contracts."

At present, Canyon Recycling is negotiating with the City of San Diego for a portion or all of the city's 60,000 annual tons of yard trimmings. The company also has proposed building a 100-acre facility to manage San Diego's biosolids under a 20-year contract.

Even without the municipal contracts, Roberts maintains Canyon Recycling will scale up to handle 200 tons per day in the near future. The company makes 15 different products that are sold to six different markets. In the San Diego area, "Vermigro," its brand of worm castings, sells for around $33 per ton on the bulk market and $120 per ton bagged for consumers. "Sales have been

good," says Roberts. "The proof is in the purchase orders, some of which we will be unable to fill until production increases."

WORM FARM PROCESSING

In Simi Valley, California, The Worm Concern has grown to a 22-acre spread during its 18 years in business. Around 100 tons per day of brush, leaves, tree limbs, grass clippings and horse manure are delivered to the site, mostly from municipal or commercial sources in Simi Valley, Thousand Oaks, Santa Rosa Valley and even Los Angeles. However, co-owner Jay Escover makes it clear that he does not see The Worm Concern as a waste processing facility. "This is an agricultural operation," he says. "Vermiculture uses organics as a feedstock for raising worms."

Part of Escover's insistence on terminology can be more clearly understood in the context of the current debate taking place in California regarding the classification and potential regulation of composting facilities. A draft of regulations released in August by the California Integrated Waste Management Board (CIWMB) excludes vermicomposting operations from the notification and permitting that would be required of most larger facilities using thermophilic composting to process yard trimmings, manure, biosolids and other materials. Worm farms traditionally have been exempted and the current version essentially doesn't change that. However, as Jeff Hunts of the CIWMB notes, these are still draft regulations and presently are "open for discussion."

"The state is working on a tiered approach to regulate composting operations," he says, pointing out that it sometimes is difficult to tell where certain kinds of facilities fit. "If part of a vermiculture operation falls into the state's final definition of a composting facility, then it could be regulated as such." Following the end of a 45-day comment period in mid-October, a testimony forum will be held. Hunts adds that the final regulations could be in place as early as March, 1995.

At The Worm Concern, incoming material first passes through a Willibald grinder and a Powerscreen trommel before being placed in windrows by a front-end loader. After 60 to 90 days in the windrow, the feedstock is moved to 100 foot long windrows where around a foot or so of new material is added each week. "Windrow preprocessing is a fairly anaerobic process," says Escover. "The piles aren't turned at all until material is moved to the worm rows."

At harvest, worm rows are scooped up with a front-end loader and placed in a small trommel screen. "Castings come out one end and the worms come out the other, unharmed," Escover explains.

Vermicastings are sold in bulk, blended on site with mulch or other landscape products, bagged for retail sale, or sold in popular, refillable two-gallon buckets.

"Worms derive their nutrients from the microbes and fungi that grow on organic matter, not the organic matter itself. As they ingest material, it is reduced in size and what comes out the other end is much more microbiologically active than what went in."

In California, interest in vermiculture has escalated over the past two years. One operator added a demonstration area for school tours.

Worm casting tea, worms, worm books and bins, and "worm soil" — a premium soil with worms and cocoons mixed in — also are available.

Some customers have expressed concerns about possible contaminants in the end product, but "there seems to be enough heat in the windrow to control pathogens and weed seeds," according to Escover. He has been promoting use of the castings to the agricultural sector and so far hasn't heard of any problems.

Education is important to Escover, who says he's seen an escalation of interest in vermiculture over the past two years, especially since passage of California's AB 939 has generators examining diversion options. He added a demonstration area to his site and offers tours of the facility to school children and municipalities.

INTEREST IN FLORIDA

In Orlando, Florida, Environmental Earthworm Projects, Inc. (EEP) is preparing to take on the institutional waste stream. Four years ago, Frank Stevenson — a long time organic gardener — bought a stock of earthworms to produce soil and began experimenting with different growing techniques. While developing an appreciation for the prodigious production capacity of worms, he met Barnell Logue, a pioneer in the field who had developed a windrow vermicomposting system to handle municipal solid waste during the 1970s. Stevenson discovered a growing interest in vermicomposting from waste managers and formed EEP with his son, George, and Logue in September, 1993.

Currently, the company operates two sites handling a combined total of 30 tons per month of composted yard trimmings from the Orange County landfill and 20 tons per month of shredded cardboard. They also have conducted earthworm trials with RDF fines from Palm Beach County and other organics.

Two projects being discussed are of particular interest. The first, in cooperation with the Palm Beach County Solid Waste Authority, would require 600 tons of worms to handle commercial organics from supermarkets and institutions. "This past year, we made it through all the budget cuts but the last one," says Stevenson, who still has hopes that the project eventually will be funded.

In another development, the University of Florida Energy Extension Service in Palm Bay has been talking with large businesses in Orange County, encouraging them to dedicate their organics to EEP's worms. Clients will be provided with clean containers to collect food, soiled paper and cardboard. (The glue in cardboard boxes is usually animal-derived, a fact in which worms take much delight, Stevenson says.) The paper products and food will be shredded and fed to the windrows.

The biggest accounts would be outfitted with an Original Vermitech system on the premises. Hotel or restaurant staff would operate the composter, with EEP servicing it periodically and harvesting the castings.

Stevenson is hoping to relocate the company's vermicomposting operations to a permitted site in the near future. If the move comes through, he'll also be negotiating to handle biosolids, he says.

PATHOGEN QUESTIONS

The digestive processes of earthworms are still imperfectly understood, but a body of knowledge is growing. "Worms derive their nutrients from the microbes and fungi that grow on organic matter, not the organic matter itself," says Clive Edwards of Ohio State University. "As they ingest material, it is reduced in size and what comes out the other end is much more microbially active than what went in."

One issue that arises regarding vermiculture as an organics management technology centers around pathogen reduction in the end product. "There is good evidence that pathogens are knocked out to a considerable extent by vermicomposting," says Edwards, who headed up an extensive research project on earthworms in England during the 1980s. "A fair amount of work has been done with *E. coli* for instance." For the most part, results of those studies apparently remain unpublished.

Dan Holcombe of Oregon Soil — and other vermiculturists — report that plant or human pathogens have never been a problem in their operations. Others, including a microbiologist who has worked with the full range of organics management technologies, suggest that some of the more resistant pathogens, especially those in spore form, have been know to survive passage through earthworms' digestive tracts.

In vermicomposting, temperatures are generally kept below 30°C, according to Edwards. "Worms can be found in thermophilic composting windrows, but they tend to stick to the edges of the pile. Temperatures above 35°C will kill them," he says. For practical comparison, meeting the requirements of the EPA's Process to Further Reduce Pathogens (PFRP) for in-vessel or aerated static pile composting of biosolids requires maintaining a temperature of 55°C or higher for three days. Using the windrow method, a temperature of 55°C or higher for 15 days or longer with at least five turnings of the windrow in that time period.

Noting the federal requirements, Edwards says that, just to be on the safe side, "it's not a bad idea to precompost material before adding worms. Otherwise, it may need to be treated afterwards."

On the positive side, people love worm castings, and consumers will pay up to three times more for them than they'd pay for most "normal" compost. Among the blessings of castings, vermiphiles count a smaller particle size than thermophilic compost, lower odor, enhanced microbial activity, and as a bonus, the vermicompost often contains worm cocoons, meaning a free work force for the future. ■