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ATTRA
Appropriate Technology Transfer for Rural Areas

# WORMS FOR COMPOSTING (VERMICOMPOSTING)

**LIVESTOCK TECHNICAL NOTE**

ATTRA is the national sustainable agriculture information center funded by the USDA's Rural Business -- Cooperative Service.

Contents:



To design a sustainable agricultural sector, the outputs from each production enterprise must become inputs to other enterprises just as in nature. Everything in the natural system is food to something else. We have not yet succeeded in mimicking this efficiency in our agricultural system.

Many organic byproducts of agricultural production and processing are currently seen as "wastes" and thus become potential environmental hazards. Likewise, leaves, lawn clippings and restaurant food wastes have become problematical because their bulk fills limited landfill sites quickly. In some instances where the "output-becoming-input" model has been tried, we may have created other dangers. Currently wastes from poultry confinement systems are fed to other types of livestock although there is some public concern about this practice.

Organic wastes can become safe soil amendments or substrate for the production of plants or feed for livestock when properly processed. Mushrooms and worms are two examples of products that can be raised on the wastes from other enterprises. Besides the primary product, the "wastes" are rendered more valuable and their volume has been reduced. Traditional composting is another way to reduce bulk and to improve the safety and general quality of organic wastes. The final result in both cases is a valuable soil amendment.

Worms eat many types of organic waste materials and convert them into "castings." This material is highly valued as a soil amendment because it contains plant–available yet stable nutrients. It is biologically active as well and apparently contains plant hormones which can provide other advantages. If it is not applied back to the soil of the farm where it is generated, castings can be marketed to the landscape industry for use in landscape plantings or as a component of potting soil mixes. Another product is the worms themselves, which can

**Vermicycle Organic, Inc., Charlotte, NC [Batch Reactor]**

From an experimental beginning on his own hog farm in 1994, Mike Edwards, along with partners Chris Christenberry and Tom Christenberry, have built their operation to four 220′ x 35′ greenhouses processing wastes from four hog farms on a ten-year contract. (They plan to expand to sixteen at this site.) Each greenhouse contains three vermicomposting beds into which hog solids are spread. The hog farmers install a solids separator between the hog facility and their lagoon. Solids are placed on a concrete pad while the remaining liquid drains into the lagoon. They are scooped up and hauled to the vermicomposting site. Farmers themselves deliver the solids to the central location in order to reduce danger of importing disease to the hog facility. The greenhouses are equipped with automatic misters, fans, greenhouse curtains, shade cloth, and fans to maintain optimal temperature and moisture conditions. Every other month the contents of each bed are removed and worms and eggs are mechanically separated from castings. Nutrient levels are determined, and castings are bagged into 10 and 25 pound bags by a contractor and into two pound bags by Vermicycle Organics, Inc. They market the 40 to 50 tons of castings to garden centers, supermarkets, and organic farmers (1, 2).

also be marketed or further processed to become a livestock feed supplement.

For the farmer with livestock confined for all or part of the year and an accumulation of manure to safely dispose of, vermicomposting may be an enterprise to consider. A method requiring very little capital investment (although it will require timely management), vermicomposting can be integrated into the farming system and provide a separate profit center.

An entrepreneur in a location where there are many confinement livestock operations can develop a vermicomposting business using the manure as a feedstock. Such a business would manage the worms as livestock themselves and then market the resulting products: vermicompost and worms. This has been done in both North and South Carolina, as a matter of fact (see boxes).

### The Process and Equipment

Vermicomposting is not really a type of composting. In fact, worms are likely to die if true composting, a heat-producing process, occurs. Vermicomposting can be seen rather as a form of livestock production. Many different materials can be used as feedstock for the worms.

Animal manures are quite useable, most without any further preparation. Hog slurries, however, must be separated, and only the solids are fed to the worms. Poultry manures may contain excess ammonia and inorganic salts and so they must be processed to remove these substances which would be toxic to the worms. Plant residues, such as potato and brewery wastes, have also been tested as feedstocks for commercial systems. As in any livestock enterprise, it is critical to maintain optimal conditions. Moisture, pH, and aerobic conditions in the growing medium must be maintained to ensure healthy, growing worm populations. Profitable production depends on both growth and reproduction rates of worms as well as on the choice of a suit-

**Oregon Soil Corporation, Oregon City, OR [Continuous Reactor Process]**

Dan Holcombe has been processing between five and seven tons of preconsumer produce from sixteen supermarkets daily for almost two years. The produce is mixed with shredded wax paper and cardboard dumped into an 8′ x 2½′ raised trough with a mesh floor. About 3 inches of material are added daily and the finished material is removed from the bottom. *Eisenia foetida*, the most commonly used vermicomposting worm, moves into the fresh material to feed and avoids contact with the scraper at the bottom. Vermicompost is sold in one–cubic–foot bags in several states (3).

**Yelm Earthworm and Castings Farm, Yelm, WA [Windrow Method and Stacked Bins]**

Jim Jensen manages two types of vermicomposting systems, including indoor stacking trays (formerly used in mushroom production) and windrows, both indoors and out. Half of the contents of the six–inch–deep trays are removed about every two months and fresh feed is added. For the windrow operation, dairy manure, the primary feedstock, is spread initially 12 to 18 inches deep in beds 4 to 10 feet wide. A pound of redworms (*Eisenia foetida*) is added for each square foot of surface area. Two or three inches of manure, either with or without bedding, is added each week. In colder weather, a deeper layer—up to six inches—is better. The size of the windrow is determined by the weekly supply of feedstock. Enough surface area must be available to handle the amount of material to be processed. When the first windrow reaches about three feet, a new one is built directly against the older one, allowing the worms to migrate to fresh feed. This process is repeated when the second windrow reaches about three feet tall. Active piles are covered with fabric compost covers (see suppliers list below). Finished compost is removed after two to six months(4, 5).

able species for the feedstuffs available. Different species have preferred ranges of temperature and moisture conditions. A review of the research on this subject is available in Edwards and Bohlen, 1996. (See "Recommended Reading" below)

Vermicomposting methods can range from a worm bin in the kitchen for household scraps to large mechanized systems able to accommodate tons of organic material on a continuous basis. In general, these methods can be grouped into four types:

1. Windrow systems on concrete or on the ground require the least capital investment, but they are slow and labor intensive, even with machinery. They are most appropriate where the castings will be used on site and worm production is not a major goal.

2. Stacked bins or containers require considerable handling and lifting. It is difficult to add moisture or feedstuffs. Monitoring bed conditions can be difficult.

3. Batch reactors (containers on legs on the ground) are filled, allowed to work, and then emptied. This type of processing is being tested at various scales throughout the US.

4. Continuous flow reactors are the most capital intensive of these systems. Equipment and housing, as well as skilled management and excellent marketing are necessary to justify such an enterprise.

In the first two types of systems, thin layers of wastes (feedstuffs) are added at frequent intervals to the worm growing area until it reaches a given depth, usually about three feet. Worms are therefore always feeding in the top layers. Finished material may be removed from the bottom of the containers. Small-scale bed systems exploit the worm's preference for fresh feed to move worms from one side of a bed to the other. Finished material is removed from the other side of the bed. The aversion of worms to light or excessive heat can likewise be used to move worms from one area to another.

Mechanical means can also be used. Screens fine enough for the castings to pass through, but too small for worms and cocoons are typically employed. Commercial separators are available. Please refer to the list of suppliers at the end of this publication. Currently, *Eisenia foetida* (known as redworm, red wiggler, or brandling worm) is the most common species used in vermicomposting. Optimal conditions for worm health and growth include maintaining the bed at 60° to 70° F (15° to 20° C), moisture at 80 to 90%, pH between 5 and 9 with oxygen present throughout the bed. Lower temperatures slow the vermicomposting process. Temperatures above 90° F are common in the composting of raw materials. It is therefore important to add thin layers when using uncomposted mate-

**JWH Industries Inc., Florence SC [Batch reactor]**

Michael James began his vermicomposting business in June of 1994 with ten raised wooden worm beds, each 4 x 8 x 1 feet and family help only . By the end of 1996, fifteen people tended more than 360 worm beds at five farms. The size of the market for worms took him by surprise. He has used several species of worms (though *Eisenia foetida* is the main one) and has tested manures, municipal biosolids, brewery filter cake, municipal solid waste, and wood pulp. Mr. James was advised by his Extension agent to use an "all in, all out" system so that the beds can be cleaned between production cycles. It has proven a good strategy to avoid mite infestations, a potential pest problem. JWH Industries developed a relationship with Nippon Jupiter Corporation of Japan through efforts of the South Carolina trade office in that country and the state's Department of Agriculture. After three trial shipments, they finally met the stringent requirements of the partner: 96% pure compost run through a 5 millimeter screen. James' attitude is, "It takes a little more labor and time, but that's okay. I like to think of it as utilizing human resources to help the worms do their job" (6).

rials and to monitor temperature continuously. Moisture meters can ensure that worms, dependent on damp conditions to breathe through their skins, can thrive throughout the bedding material.

In systems that control temperature, pH, and moisture, and employ the right type of worm, use enough of them, and balance feed rations, the production of compost can prove profitable. Such operations must be handled as enterprises even if they are part of an integrated farming system. They require attentive management and a certain amount of time. Some producers may not have time or money to create the highest yielding vermicompost system. They can still choose a slower, lower–input method and produce a valuable product. For others, the marketing required may prevent choosing the highly productive and potentially profitable controlled system. Nevertheless, vermicomposting offers opportunities for those whose operations and interests are well-matched.

## Economics

The economic value of products from vermicomposting confinement livestock wastes may not justify the cost of an intensive system, but the benefit to society as a whole might count them worthwhile. Practices such as applying too much manure directly on agricultural land and holding liquid wastes in poorly designed lagoons have, in some cases, resulted in very high nutrient levels in ground and surface waters. If confinement livestock operations are unable to ensure the protection of water and soil resources using current practices, processing the large amounts of wastes they generate becomes a community concern.

Composting and vermicomposting are two methods of converting these highly concentrated "wastes" into valuable resources. Whether these benefits can be translated into profits through vermicomposting depends upon many factors.

In any business or farm enterprise, the anticipated return on investment must be carefully considered before one commits to it. For large scale vermicomposting units, operating costs are the most important consideration. On the other hand, for smaller units the capital expenses associated with setting up the system are the most expensive item. For a medium sized livestock operation, a low tech system requiring skilled management may make the most economic sense, if operations can be planned so that peak labor seasons can be coordinated.

Economic viability depends primarily on the price received for the compost. Marketing this product is therefore a critical activity. Worms sold for bait are an additional source of income (see sample 1994 worm production budget).

**Sample Budget for Earthworm Production**

This budget assumes bait sales of 168 pounds of earthworms per year from a wooden worm bed with a 42 square foot surface area and a yield of 4 pounds of worms per square foot. The expected lifetime of the investment is five years.

| | UNIT | PRICE | QUANTITY | AMOUNT |
|---|---|---|---|---|
| **Receipts** | | | | |
| Bait Sales | 100/pint | $1.00 | 840 | $840 |
| Other sales | | | | |
| Total receipts | | | | |
| **Variable Costs** | | | | |
| Feeding labor | hour | $5.00 | 52 | $260.00 |
| Feed * | | | | $ 0.00 |
| Harvest labor | hour | $5.00 | 60 | $ 300.00 |
| Packaging | pint | $0.10 | 840 | $ 84.00 |
| Advertising | | | | $ 0.00 |
| Other var. cost | | | | |
| Total var. costs | | | | |
| **Fixed Costs** | | | | |
| Initial investment | bed | 63.24 | 1 | $ 63.24 |
| Other fixed costs | | | | |
| Total fixed costs | | | | |
| **Total Costs** | | | | $707.24 |

Initial resource requirements

Wooden worm bed (42 sq. ft. area): $316

Feeding labor: 1 hr./bed/wk., 52 wks./yr.

Harvest labor: 3 hrs./bed/wk., 20 wks./yr.

*Harper, Jayson K. and George L. Greaser. 1994. Agricultural Alternatives: Earthworm Production. PennState College of Agricultural Sciences Cooperative Extension. p. 4.*

They generally bring higher returns than worms processed and sold as a protein feed supplement for poultry or fish. However, the market requires only a limited number of bait worms. Some additional worms can be sold to other people interested in vermicomposting or bait-worm businesses if this market is developed.

Commercial vermicomposting is just beginning in this country. San Diego, California, has employed worms to convert part of its organic waste stream into useable products. The castings are reportedly in high demand. In Oregon, a research/demonstra-tion project has become a thriving business. The Oregon Soil Corporation uses a continuous flow reactor. A large urban hospital in Ontario likewise has been using worms to process some of its waste stream for several years.

Countries other than the US have been researching and using commercial systems for a decade or more. Cuba, in particular, has relied on reusing its organic wastes since its supply of petroleum has been curtailed. Vermicomposting has been investigated as a way to convert some agricultural wastes into a soil amendment for more than ten years. Currently France, Germany, Italy, Japan, Hong Kong, India, Australia,

and many countries in South America have research or commercial vermicomposting projects underway.

### Further Information:

Listed below are several key reference books as well as publications, an association, and sites on the Web which address the subject of vermicomposting. In addition, Biocycle will publish Manual on Vermicomposting, edited by Clive Edwards, one of the world's foremost writers on the subject, in 1999. This book will likely be worth obtaining when available.

#### Recommended reading:


Bogdanov, Peter. 1996. Commercial Vermiculture: How to Build a Thriving Business in Redworms. Vermico, Merlin, OR. p. 64-66.
Available for $25 plus $3 shipping from Vermico (contact information below in the periodicals section)

Edwards, C.A. and E. Neuhauser (eds.). Earthworms in Waste and Environmental Management. SPB Academic Publishing BV, The Hauge, The Netherlands. Available for $110 ppd. from:
Flowerfield Enterprises
10332 Shaver Rd.
Kalamazoo, MI 49024
(616) 327-0108

Edwards, C.A. and P.J. Bohlen. 1996. Biology and Ecology of Earthworms (3rd ed.). Chapman & Hall, London. 426 p.

Lee, K.E. 1985. Earthworms: Their Ecology and Relationships With Soils and Land Use. Academic Press, NY. p. 173-182, 205-213.

Satchell, J.E., (ed.). 1983. Earthworm Ecology: From Darwin toVermiculture. Chapman and Hall, NY. 495 p.


#### Further Reading:


Holcombe, Dan. n.d. Blueprint for a Successful Vermiculture System. Oregon Soil Corporation, 1324 Beaver Lane, Oregon City, OR 97045.
[tel. Dan Holcombe: (503)658-8342]
Includes building plans for a complete small scale commercial vermicomposter which can be scaled up for larger operations.

Bhawalkar, Uday. n.d. Vermiculture Ecotechnology. Bhawalkar Earthworm Research Institute, Pune, India. 380 p.


#### Worm Book Sellers


Arlan & Sons, 11881 Arroyo Ave., Santa Ana, CA 92705. (714) 838-8539, (800) 322-2252. Fax (714) 838-4950. E-mail arlan@neptune.net

Lewis Publishers, 121 South Main Street, P.O. Box 519, Chelsea, MI 48118. (313) 475-8619 Fax: (313) 475-8650.

Rodale Press, 22 Main St., Emmaus, PA 18098. (610) 967-8108 Fax (610) 967-8959.

Shields Publications, P.O. Box 669, Eagle River, WI 54521. (715) 479-4810.


### Eden Farm, Eden, MD [Open Field Block Method]

Mike Banks, at his farm in Eden, Maryland, has been experimenting with an open field block method of vermicomposting since 1994. His system is different from most others currently in use because he uses *Pheretema elongata*, a deep burrowing type of earthworm, native to India. His pilot site is 130 by 120 feet of open ground with an underground irrigation system. He has added 480 cubic yards of yard trimmings, eggshells, manure, and hay to the area in 13 months. About three inches of organic materials (he has experimented with many different ones) are spread over the top by a side-slinging manure spreader at seven to ten day intervals. "Odors are an indicator that something is wrong," says Banks. "When the ratio of materials is right, there is no appreciable odor the day after new feedstock has been applied." He intends to continue developing the technology until he is comfortable with it, then expand, possibly to an area of several acres (3).

**Worm Book Sellers: (continued)**

Van Arsdale's Worm Sales, POB 182, San Jacinto, CA 92581 (909) 654-1970 Fax: (909)-654-1970.

**Periodicals with Vermiculture Information:**

Worm Digest
Box 544
Eugene OR 97440-9998
(541) 485-0456
Zorba (e-mail: zorba@wormdigest.org)
4 quarterly issues for $12.00
http://www.wormdigest.org

Casting Call
VermiCo
P.O. Box 1134
Merlin, OR 97532
(541) 476-9626
Peter Bogdanov (e-mail: vermico@cdsnet.net)
http://www.nwim.com/vermico
6 bimonthly issues for $18.00

WormWise News
International Worm Growers Assn.
P.O. Box 900184
Palmdale, CA 93590
(805) 944-2994
Quarterly publication free to members

Composting Rules: A Summary of Legislative and Regulatory Issues
The Composting Council
114 Pitt St.
Alexandria, VA 22314
(703) 739-2401
12 issues for $63

BioCycle: Journal of Composting & Recycling
419 State Ave.
Emmaus, PA 18049
(610) 967-4135
Monthly publication; $63/year

Waste Age
P.O. Box 420183
Palm Court FL 32142-9924
(800) 829-5411
one year 12 issues free if qualifies; if not $55

Recycling Times
P.O. Box 420186
Palm Court FL 32142-9949
(800) 829-5443
one year 26 issues $99

Resource Recycling
P.O. Box 10540
Portland, OR 97210-0540
(503) 227-1319
one year 12 issues $47; two years 24 issues $73

**Worm Web Sites:**

The Compost Resource Page: Large-Scale Composting
http://www.oldgrowth.org:80/compost/large.html

The Compost Resource Page: Vermicomposting
http://www.oldgrowth.org:80/compost/vermi.html

Mr Ken's Wide Worm Links:
http://www.wans.net/~thegarys/mr.kensworld/webworms.htm

Soil Solutions
http://www.soil-solutions.com/index.html
http://www.soil-solutions.com/soil4.htm

Worm Digest
http://www.wormdigest.org

Brian Paley's site
http://gnv.fdt.net/~windle/

Beaver River on Merchants Bay
http://www.merchantsbay.com/beaverriver/

**Internet List:**

Send message to LISTSERVE@maelstrom.stjohns.edu with following command in the body of the email:
SUBSCRIBE WASTENOT FIRSTNAME LASTNAME

**Worm Association**

Global Vermiculture Association
David Anderson
(817) 571-4852
02/03 - The previously listed website for this organization has been changed.

**Consultants and Sources of Worms and Equipment:**

Enviro-Ganics
P.O. Box 20241
Grantham Postal Station
St. Catharines, Ontario L2M 7W7
Sandra Kandracs
(905) 646-8690

Environmental Earthworm Projects, Inc.
8114 Port Said St.
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 Corporation
7825 Fay Ave. Suite 380
Suite 380
La Jolla, CA 92037
Joseph Roberts
(618) 551-4800

Vermi-Organic Digesters
available from VermiCo (see above under periodicals)
(514) 476-9626

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

**Compost Cover Suppliers:**

Autrusa Co., P.O. Box 1133, Blue Bell, PA 19422, (610) 825-2973, E-mail George Leidig for information: autrusa@aol.com. Website: http://www.autrusa.com
*Suppliers of: Top-Tex Compost Cover.*

Texel, 245 Ten Stones Circle, Charlotte, VT, (802) 425-5557, E-mail Steve Wisbaum for information at: wisluria@together.net.
*Suppliers of: Compostex Cover.*

**References:**


1) Raufer, Bill. 1997. Earthworms: Digging up manure solutions. Pork. June. p. 78, 80, 82.

2) Riggle, David. 1996. Redworm resources: The business of vermicomposting. BioCycle. September. p. 54-6.

3) Riggle, David. 1996. Worms make the grade: Scaling up for commercial vermiculture. BioCycle. February. p. 39-40, 42, 4.

4) Anon. 1997. Interview with Jim Jensen. Casting Call. p. 5-8.

5) Jensen, Jim [Yelmsworms@aol.com]. 1997. Vermicomposting. October 13. 4 p.

6) Riggle, David. 1997. Worm markets: Vermicomposting in the Carolinas. BioCycle. January. p. 71-72.



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