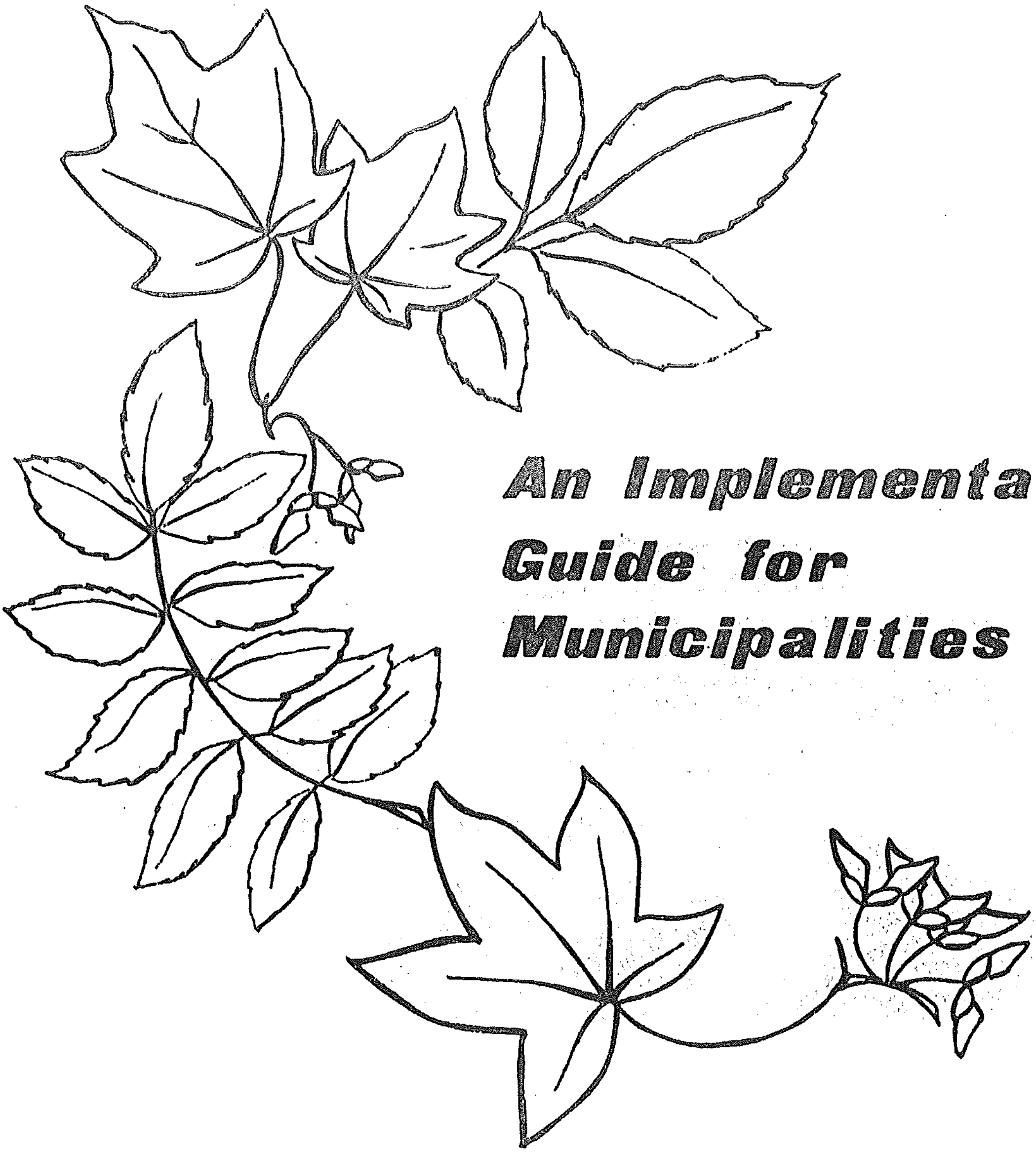
LEAF COMPOSTING



An Implementation Guide for Municipalities

Minnesota Pollution Control Agency
Solid Waste Division

JULY 1980

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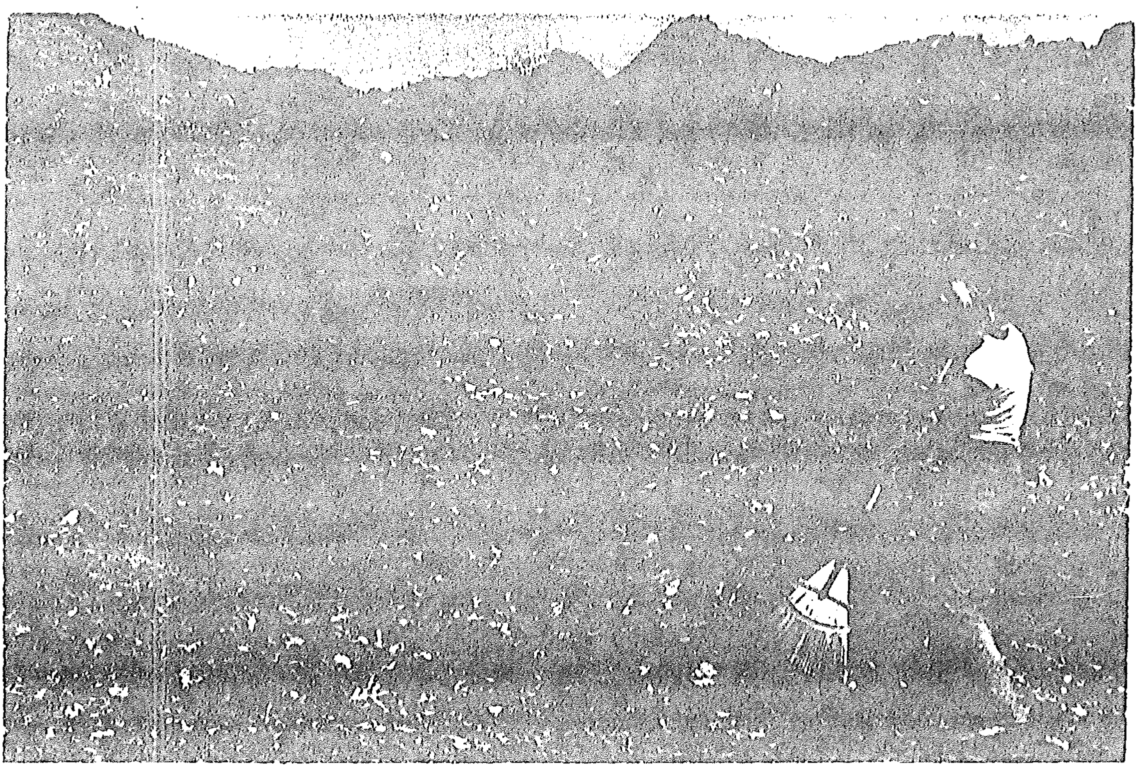


Introduction

This manual is directed to communities interested in composting leaves. Communities that already possess curbside leaf pickup will find conversion to a compost program relatively simple. Communities that have normal refuse pickup will find implementation of curbside leaf pickup much less expensive. However, no matter what leaf collection system exists, be it public or private, the adaption of that system to leaf composting is often easy and economical.

This report deals with procedural and operational strategies for any type of community interested in establishing municipal leaf composting.

The composting of leaves is a simple and environmentally beneficial alternative to landfill disposal or burning. When landfilled, leaves do not compress well and use up valuable landfill space. Open burning increases air pollution and incineration involves high costs.

The composting process is an attempt to copy the pathways of degradation occuring in nature, but concentrating them in time and space. Not only does composting solve a solid waste management problem, it converts the valuable organic matter available in leaf material into a useful mulch and soil conditioner. This compost product has many excellent properties. It improves the porosity of the soil, builds it up with organics, increases water retention, tilth, and permeability, and reduces surface crusting and erosion. Composted leaf mulch can also provide nitrogen, phosphorus, and potassium to the soil in small amounts, as well as provide other essential micronutrients. Leaf compost has the following general composition: Nitrogen - 0.8%, Phosphorus - 0.5%, Potash (K_2CO_3) - 0.3%, and Iron (Fe), Zinc (Zn), Manganese (Mn), and Copper (Cu) — 3 - 500 ppm each.

The degree to which leaf composting is an economic waste-disposal practice will vary from community to community. Generally, however, it is the cheapest overall alternative. A community's major considerations should be:

1) The economics of alternative disposal methods

2) The availability of land for a compost operation

3) The feasibility of a compost give-away program or other marketing strategy

4) The extent of the leaf generation problem

5) The leaf collection strategies available, i.e. pickup and drop-off options, and

6) The overall environmental awareness of the community.

Composting Methods

The most widely accepted method for leaf composting is the windrowing process. A windrow is a long pile of organic material, ten to twelve feet high and ten to twelve feet wide, roughly triangular in cross-section, and as long as space permits. The piles are turned periodically (once a month if possible) with a front-end loader or other turning machine to promote aeration and mixing. The more the pile is turned, the faster the material decomposes aerobically (with oxygen). If the pile is not turned regularly, anaerobic conditions (i.e. without oxygen) and foul odors can occur. These odors originate from methane, hydrogen sulfide, mercaptan and/or skatole gases.

Mechanical composting, which differs from the windrow process, is not a very practical method for leaf digestion because of its rather high cost and relatively low yield. Leaves, because of their high carbon/nitrogen ratio, (approximately 80) take a long time to break down, regardless of the process used. The ideal carbon/nitrogen (C/N) ratio for composting is about 30. Thus, the C/N ratio can be lowered from 80 to 30 by adding supplemental nitrogen. Windrows are preferred because they lend themselves very well to being formed by trucks dropping their load of leaves in straight rows. Windrows also are more easily handled and provide adequate aeration when turned.

To form a leaf windrow, the material is piled into a long row. Shredding would speed decomposition at this point, but this may be impractical because most shredders will not handle fresh leaves. Next, the material is wetted down to a 40 - 60% moisture content, or until the water runs off the sides of the pile without soaking in anymore. Shredding is an optional part of the windrowing process, but moisture content is essential. The water is necessary for microbial growth, in addition to keeping leaves from blowing and preventing fire hazards. Stacking of the leaves into windrows must be gentle in order to fluff up the material to aid in aeration and avoid compaction and compression. The larger the windrow, the more insulated it will be, thus enabling it to withstand subzero winter temperatures. A cross-sectional area of seventy-two (72) square feet (twelve feet high by twelve feet wide) will ensure continued internal bacterial action during the winter months in Minnesota. If the tops of the windrows are cupped, that is, formed in a concave depression, rain will be more easily trapped and additional watering will usually be unnecessary.

Some leaf composters add an inoculant of soil micro-organisms including bacteria, actinomycetes and fungi. This addition is not essential but may speed up the composting process. Certain materials without a starter bacterial population, such as straw and clean leaves, usually require artificial inoculation. Leaves mixed with soil or leaf mulch generally do not require an inoculant. Generally, an inoculation program adds consistency to the process by decreasing variability. That is, all windrows start out with the same starter bacterial population. Addition of nitrogen in the form of urea (45-0-0 urea fertilizer), sewage sludge, grass clippings, or ammonium nitrate also hastens decomposition. Multiple shredding is another time saver, but these options have to be weighed in light of a community's particular economic factors and time constraints.

After the leaves have stood for about a week, internal pile temperatures reach peaks of 140° - 160°F (60° - 71°C). This indicates aerobic bacteria are breaking down the organic material and giving off heat as a by-product. These high temperatures sterilize the material, killing potential pathogens and weed seeds. At the end of this time, most of the oxygen in the windrow will have been depleted. At this point, the pile is turned to be reaerated to allow continuous gas exchange. Although lower ambient temperatures of winter slow the composting process, decomposition will still occur, but at a reduced rate. Internal temperatures remain high, encouraging mesophilic and thermophilic micro-organisms to thrive (i.e., those that thrive at 68 - 113°F/20 - 45°C and above 113°F/45°C, respectively). Snow acts as an insulating blanket over the windrows, although some composters add a cover of finished leaf mulch to ensure extra insulation beneath the snow and ice. Turning the piles during the winter is a matter of debate. If temperatures are very cold and the piles small, too much internal heat will be lost and thus slow or halt the composting process. If on the other hand,

Leaf windrow

the temperatures are moderate and the windrows large, then turning will be beneficial and hasten the leaf decomposition. Letting the piles "hibernate" over the winter will result in anaerobic conditions internally, but these odors will be contained by the pile itself. During the composting process, a tenfold volume reduction will take place. Spring turning and aeration may release some foul odors and gases. Some composters turn their piles in March, letting the release of any disturbing odors occur at a time when most homes are tightly closed with storm windows. Through this practice, odor nuisance can be kept to a minimum. The length of time that odors will be released will be relatively brief, since most anaerobic piles can be made aerobic within two or three days.

Odor problems can also be reduced or avoided by siting leaf composting operations in non-residential areas or at least a hundred or more yards from the closest resident.

A more drastic solution to spring odor problems would include housing the windrows in an enclosed structure, thus containing the off-gases. This alternative, although costly, would probably only be needed if the operation used sewage sludge as a nitrogen supplement and if the location of the composting site was in a residential area. Other enclosed structures used to contain odors include mechanical digestion devices, such as drums or digestion tanks. These are also very costly and usually not applicable to leaf composting.

With the arrival of spring, the nearly finished leaf mulch can now be easily shredded since it is mostly decomposed and is more acceptable to a shredder. This operation speeds final stabilization and maturation of the material, making the compost ready for public pickup during April and May. The material can also be screened to remove rocks, twigs, and other debris before becoming available for use. Some shredders incorporate screens into their mechanism.

If the alternative procedure involving static piles is employed (limited shredding and no inoculant or turning), a period of 1 - 2 years will be necessary for final leaf compost maturation. With this method, a period of time ensues with no compost products until after the first turn-over (after 2 years). Static piles may result in some odors; however forced aeration reduces this problem. This involves either placement of perforated pipes underneath the piles which pull air through the windrows or injection of air through spikes or rods. This method has been used extensively at the

St. Paul citizen dropping off leaves

Beltsville Agricultural Station in Maryland involving sewage sludge mixed with wood chips. The process is adaptable to leaves but is usually considered too costly and involved.

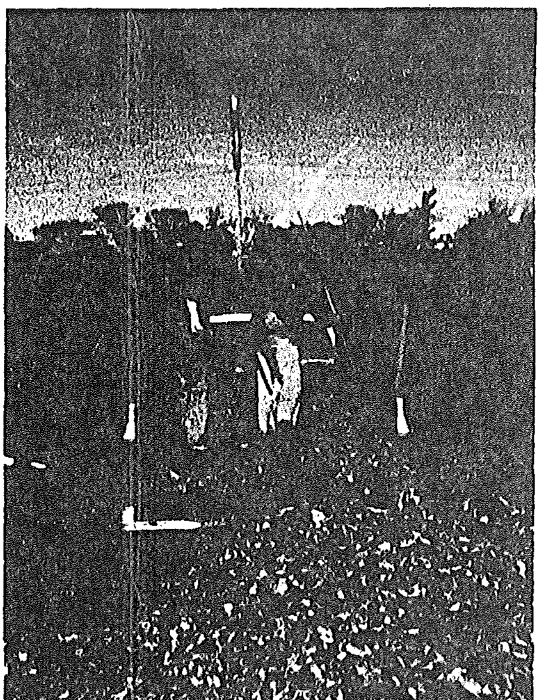
Land Requirements and Utilization

Land requirements for leaf composting can be estimated in many ways. Generally, 5000 - 7000 cubic yards of leaves can be composted on an acre of land. Another rule of thumb is one acre for each 30 curb miles, assuming a home density of 800 - 1000 per square mile.

A site with an impervious substrate is generally required to prevent leaching and also facilitate operation of heavy equipment. Good drainage is essential to help avoid anaerobic conditions; thus, the site should be slightly sloped. The windrows should run with the grade in order to prevent diking. Other site essentials include close proximity to the leaf source (urban areas) and to access roads. The location of the site must also be based on information on the projected traffic loads.

Some schools of thought assert that a semi-permeable site surface is necessary to promote seed inoculation of the incoming leaves. That is, the old leaves from previous years of composting contain essential micro-organisms needed by fresh incoming leaves. This practice would take the place of adding an inoculum, except for the first time around. One draw-back might include the problem of equipment operation on a soft substrate. The problem of leachate with a permeable substrate would pose no real problem unless sewage sludge were used in the composting process. An eastern leaf composting operation uses basaltic "trap rock" as a permeable substrate, which is less costly than black top and also provides support for heavy equipment.[2] A decision on the type of substrate needed for a given operation must be based on existing conditions and constraints.

Overall, the environmental impact of a leaf composting site is less than a sanitary landfill or refuse/sludge composting operation; however, siting problems may still occur as a result of citizen opposition. To avoid misinformation and negative citizen reaction to the project, a program of public education and participation should be carried out before, during, and after the proposed compost operation. In this way, citizens will have influence upon and access to reliable information concerning the project. A leaf composting facility is suitable to locate in a park area or other frequented site.



Pick-up truck used for collection

Other siting requirements include legal procedures and permits. A permit for a composting operation that is larger than household size must be obtained in accordance with MPCA Solid Waste Disposal Regulations # 4 and # 8. (See Appendix A for further information, or for assistance, contact the MPCA at 612/296-7373 or write the Division of Solid Waste, Minnesota Pollution Control Agency, 1935 West County Road B-2, Roseville, Minnesota 55113.)

Equipment for Transportation and Shredding

Equipment needs depend on the extent to which existing equipment can be used or modified for a composting operation. For leaf pickup, vacuum collection trucks work well under dry weather conditions. They are used in conjunction with blower units which form the leaves into piles for vacuum pickup. The fan in the truck shreds the leaves to a certain extent, thus aiding in compaction and space utilization. For larger quantities of leaves, or for ones that are wet, a front-end loader is used in conjunction with a street sweeper which is equipped with an attached buncher or plow and a water wagon. The water wagon wets down the leaves in order to aid in handling and reduce blowing problems. The sweeper then collects the leaves into piles, and the front-end loader picks them up and puts them in a waiting dumptruck. Vacuum trucks are not used for wet leaves because they tend to bog down and work inefficiently. The fan units in the vacuum trucks are also sometimes damaged by large sticks or rocks from the street, and thus, are sometimes rejected in favor of front-end loaders. If the shredding of the leaves is desired, many different units are available. (See equipment list, Appendix B.) A screen or trommel may also be utilized if a finely textured homogenous end product is desired. If an inoculant is desired, special equipment is needed for application. This includes a sprayer truck in which the inoculant can be mixed in with the water and then applied as a spray to the windrows. Smaller operations can apply inoculant by hand. More information can be obtained from inoculum companies as to correct application rates and procedure. (See Appendix C for further information.)

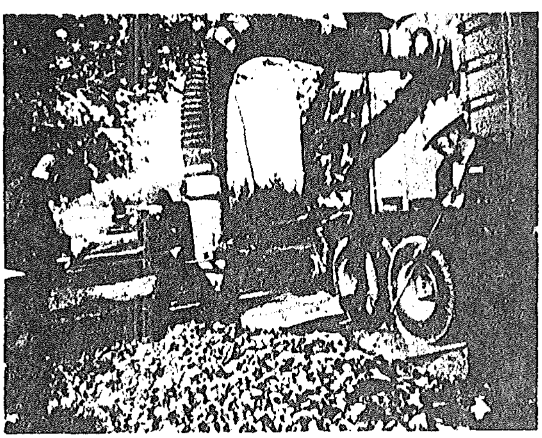
Transportation of leaves to the site usually occurs in the leaf pickup vehicle. Citizens can also assist in bringing leaves, but it must be stressed that the leaves should be taken out of the plastic bags since these bags do not biodegrade. Biodegradable paper bags are available for leaves if patrons insist on bagging them. Citizen participation can be encouraged through public education. Residents must be instructed to rake leaves to the curb, in cooperation with published collection schedules. Once people understand the procedure of leaf composting and use the leaf mulch in their gardens, they will be more receptive to continuing the project.

Experience has shown that there is little difficulty in giving away the finished leaf compost. For example, most of the material is picked up within a 2 - 3 week period at the Hennepin County Leaf Recycling Project.

Additional marketing strategies may be desired if a large quantity of compost is to be produced. These strategies include:

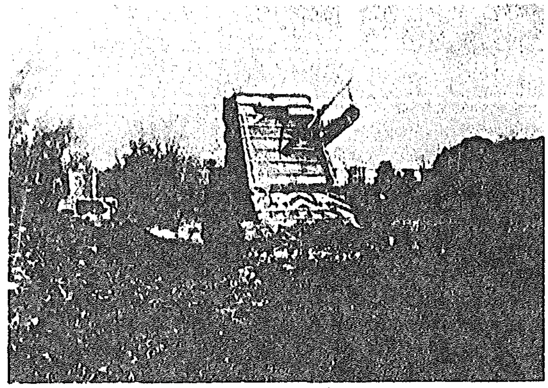
1) Identification of the leaf mulch by an appropriate logo,
2) Advertisement through radio, television spots, newsletters, fliers, billboards, pamphlets, news releases, etc., and
3) Bagging the material in attractive bags with the logo and pertinent information on the package.

Of course, these strategies would involve some monetary expenditures and, therefore, must be weighed against several factors. Perhaps some sort of coupon could be given to citizens who participated in the fall leaf drop-off program, such as allowing them free compost in the spring. This would encourage fall leaf drop-off involvement. Marketing strategies may, however, be unnecessary since all existing projects in Minnesota are having no difficulties in getting rid of all compost through give-away programs.


Vacuum truck leaf collection

Collection Costs

The following cost data were derived from the Royer Foundry and Machine Company, Kingston, Pennsylvania. The data are averaged from several communities in the metropolitan New York area.


Vacuum truck dumping leaves

In New York City, the collection period is 6 - 8 weeks, and typically, collections are once a week. Five-man crews (2 truck drivers, 1 operator for vacuum collection, and 2 rakers) with 2 trucks (16 cubic foot boxes) and 1 vacuum collector are used.

With the truck alternately collecting and delivering to the composting site, the average crew will service 4 - 6 curb miles per day. The total number of crews required will depend upon the frequency of the pickup and total curb miles. The average costs for the communities in this example were $38.00 to $47.00 per curb mile for each pickup and $228.00 to $282.00 per curb mile per season (June, 1979 figures). This figure includes labor, maintenance, and equipment depreciation for an average of 6 pickups per season.

In another example with three-man crews and 1 truck per crew, the total costs are approximately the same.

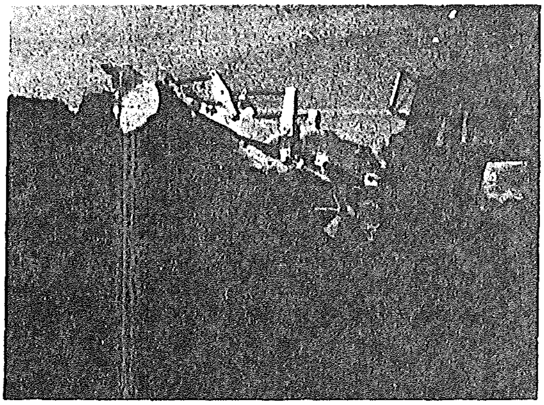
Composting Costs

The economics of composting depend on the complexity of the process chosen. Of the four options outlined in the flow diagram on page 10, the first is a do-nothing option, the second has moisture added, the third includes an inoculant, and the fourth adds a shredding operation.

The prices are:

Option	Cost of Composting (per ton of leaves)	Cost of Curbside★ leaf pickup (per ton)	Cost of Normal★★ refuse pickup (per ton)
1) Do-nothing	$ .25	$4.00	$50.00
2) Moisture added	0.60	4.00	50.00
3) Inoculant added	1.25	4.00	50.00
4) Shredding added	3.35	4.00	50.00

Costs include shredder rental or amortization, compost culture, city equipment, and labor.



Front-end loader aerating piles

★ This cost figure includes 200 cubic yards of leaves per curb mile of pickup, with curb leaves weighing 100 pounds per cubic yard. Operational costs are $42.50 (averaged value) per curb mile of pickup. Cost data was derived from the Royer Foundry and Machine Company, Kingston, Pennsylvania. Data represent several metropolitan New York communities. (June, 1979 figures)

★★ This cost figure includes $1.45 per stop, with each stop serving a 4-member home. Generation rates are 2 pounds per person per day. (June, 1979 figures)

Generally, the more expensive the process, the quicker the operation; the time may be as long as 2 years or as little as 4 - 6 months. Land costs are not included in the figures, and it must be recognized that option one requires more land space than option four because of the longer storage time required.

On choosing the method for your community, several factors must be considered:

1) Quality of product desired,
2) Funds available for the project,
3) Possibility of using existing equipment,
4) Land/time availability, and
5) Quantity of leaves available.

It can be seen that leaf composting costs vary depending on the process and complexity involved.

Another cost bonus to leaf composting is the savings gained by not sending leaves to a landfill. Landfill tipping fees generally run from $6.00 to $12.00 per dry ton.[3] This cost would thus be saved through composting.

Environmental Impacts

The negative environmental impacts from leaf composts on land, air, and water are minimal. Odor may be a temporary problem when anaerobic windrows are broken up in the spring. Odor problems can be reduced with more frequent turning or forced aeration.

Addition of sewage sludge, or other nitrogen sources may increase the potentials for odors and leachate. Careful monitoring and control of compost operations involving these materials is essential. An impermeable surface with a holding pond is advisable for collecting leachate, if sludge is used.

Problems arising from Aspergillus sp. spores are slight due to the low wood content of the leaves.

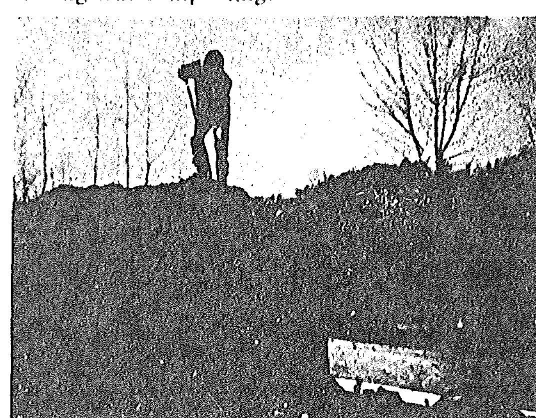
Conclusion

The feasibility of a leaf composting program depends on its successful establishment and continuance, along with public participation and involvement.

The simplicity and low cost of the operation make it acceptable to most communities. Another benefit includes increased landfill capacity due to recycling of the leaves.

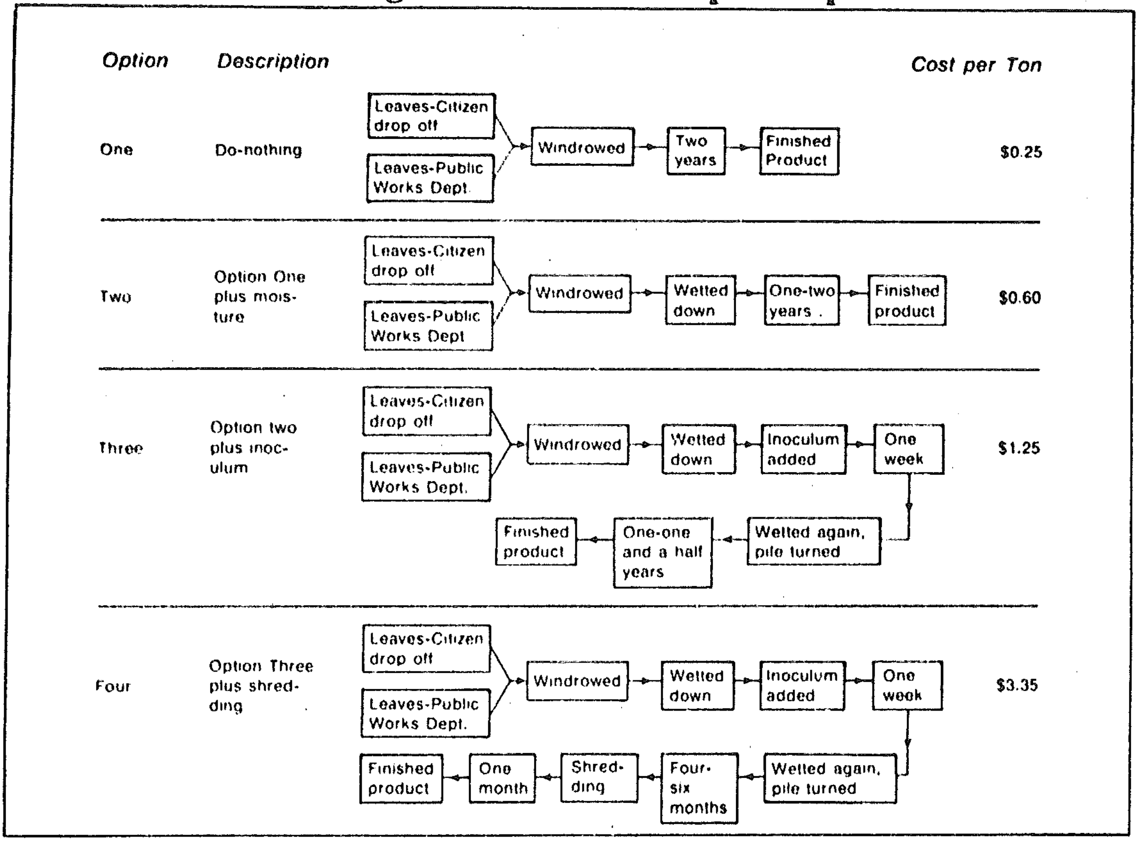
The indirect benefit of environmental enhancement is an added bonus for a community.

The MPCA is available for technical assistance and is willing to answer any and all questions concerning leaf composting.



Citizen pick-up of compost

Flow Diagram of Leaf Compost Options



These costs reflect Hennepin County figures. Saint Paul leaf composting costs are higher due to shredder rental. Saint Paul estimated economics for option number four (4) are $7.60 per ton.

Note: Hennepin County owns its own shredder. Other factors used in the above flow diagram include:

- one cubic yard of leaves weighs approximately 575 pounds.
- one cubic yard of finished compost (leaf mulch) weighs approximately 1200 pounds.
- land costs are not included.
- inoculum costs are $1.30 per pound. Dosage is one-half pound per ton of leaves.
- economics reflect June 1979 figures. Additional options include adding supplemental nitrogen (N), increasing the turning rate, using forced aeration (Beltsville method), and/or bagging the final product.

APPENDIX A

Minnesota Pollution Control Agency Solid Waste Rules

SW 8 Composting

(1) It is unlawful for any person to install or alter any composting operation without first having been issued a permit by the Agency. (See also SW 4)

(2) When a permit is desired, the following details shall be submitted to the Agency for review, prepared by a registered engineer of Minnesota.

(a) A minimum of three sets of plans and specifications, folded to 8½ inch by 11 inch size, clearly indicating the layout and construction which will be undertaken.

(b) A minimum of three sets of maps or aerial photographs indicating land use and zoning within ¼ mile of the facility. The map or aerial photograph shall be of adequate scale to show all homes, buildings, lakes, ponds, watercourses, wetlands, dry runs, rock outcroppings, roads and other applicable details and shall indicate the general topography with contours and drainage patterns. Wells and soil boring locations should be identified on the map or aerial photograph.

(c) Details relating to gelogical formations of the property whereon the proposed installation is to be located. Such details shall be determined by soil borings or other appropriate means to a depth of at least ten feet. The high water table should be inclued.

(e) Information relating to Regulation SW 5.

(f) Owner of the site and/or plant.

(g) Persons responsible for actual operation and maintenance of the plant.

(h) Additional data or information may be required by the Agency.

(3) The operation shall be conducted in a manner which minimizes pollution, public health hazards and nuisances.

(4) Materials resulting from composting or similar processes and offered for sale shall contain no pathogenic organisms, shall not reheat upon standing, shall be innocuous, and shall contain no sharp particles which would cause injury to persons handling the compost.

(5) By-products removed during processing shall be handled in a pollution and nuisance free manner and shall be disposed of as provided in these regulations.

(6) Reports describing the types and amounts of waste composted, the amount of compost produced, and the amounts of by-products removed and the disposition of the by-products shall be submitted to the Agency every month together with other information on the operation of the compost plant.

Filed January 12, 1970

SW 4 Intermediate and Final Disposal of Solid Waste

Open burning is prohibited at all intermediate and final solid waste disposal sites, except as shall be allowed by any regulations of the Agency now or hereafter adopted.

Solid waste shall not be deposited at any intermediate or final solid waste disposal site in such a manner that material or leachings therefrom may cause pollution of ground or surface waters.

A person shall make an intermediate or final disposal of any solid waste, only at a site or facility for which a permit has been issued by the Agency unless otherwise provided by these regulations. Permits shall not be required for sites used for the disposal of solid waste from only a single family or household, a member of which is the owner, occupant or lessee of the property, under these regulations, but these shall be operated and maintained in a nuisance-free, pollution-free and aesthetic manner consistent with the intent of these regulatons.

Disposal of toxic and hazardous wastes shall be in a safe and pollution-free manner and in compliance with the regulations of federal, state and local governments and their regulatory agencies.

Filed January 12, 1970

APPENDIX B

EQUIPMENT MANUFACTURERS AND DISTRIBUTORS

(Shredders and Screens and Compost systems)

Allis Chalmers, Inc. Solid Waste Processing 3033 West Spencer Street Appleton, Wisconsin 54911 Contact: Robert Brickner (414) 734-9831	Large-Capacity Shredder System
Detroit Stoker Company 1510 East 1st Street Monroe, Michigan 48161 Contact: Jim Hall (313) 241-9500	Detroit Crusher-Shredder Complete line of shredders; horizontal feed and shredding design; discharge sizing grid
Gruendler Crusher and Pulverizer Company 2915 North Market Street St. Louis, Missouri 63106 Contact: Mike Kerper (314) 531-1220	Leaf Shredder reduces leaf volume by 17 - 1; prepares leaves for mulch or composting; vacuum intake, gasoline or diesel powered; shreds from 25 - 250 cu. yds./hr.
The Heil Company 300 West Montana Street Milwaukee, Wisconsin 53201 Contact: Paul Miller (414) 647-3333	Heil shredders. Municipal, commercial, and industrial applications; dual rotation on hammers for long life; large, nonshreddable objects are ballistically rejected; up to 80 tons per hour cap.
Koppers, Inc. Sprout-Waldron Division Waste Processing Dept. Muncy, Pennsylvania 17756 Contact: K.A. Sterrett (717) 546-8211	Components for Aerated Pile Composting Systems. An assortment of equipment including double agitated mixers, trommel screens, material handling systems, storage bins and blower fans.
Lindig Manufacturing Corp. 1875 West County Road C St. Paul, Minnesota 55113 Contact: John Lindig (612) 633-3072 $18,000 shredder	Screens. Ability to screen compost, sludge, wood chips, and topsoil, among other materials; rubber paddle feeder; cleaning brush assembly: provides important aeration, mixing and texture control of finished sludge compost; shredder attachment reduces compost compaction.

Royer Foundry and Machine Co.
P.O. Box 1232
Kingston, Pennsylvania 18704
Contact: Charles Otto (717) 287-9624

Royer Shredder. Processes composted or digested sludge with leaves into a useful soil conditioners; shreds, cleans and aerates; 125 cubic yds. per hour capacity; all hydraulic diesel powered; smaller sizes available.

Organic Processing Systems, Inc.
1222 East 26th Street
Erie, Pennsylvania 16504
Contact: John Bartone (814) 456-0089

OPS Plants. Accepts organics ranging from wood chippings and leaves to shrub and grass clippings to garbage and sewage sludge; shredding unit available to texturize end produce.

Resource Recovery Systems of Nebraska, Inc.
Route 4
Sterling, Colorado 80751
Contact: Les Kuhlman (303) 522-0663

Scarab. Windrow turner; flails, aerates, and fluffs organic wastes; straddles 14 foot wide pile; capable of turning up to 1500 tons of organic wastes per hour; diesel powered; hydrostatic drive.

VACUUM LEAF COLLECTORS

Vac-All: Fox Leaf Vac 570
Super Vac Leaf Loader

Dealer: Ruffridge-Johnson Equipment Company, Inc.
3024 S.E. 4th Street
Minneapolis, Minnesota 55414
(612) 339-7937

Company: Koehring Farm Equipment Division
3800 Wisconsin Avenue
P.O. Box 1279
Appleton, Wisconsin 54912
(414) 739-3631

Unit handles leaves, wood chips, sludge, and twigs.

Truck units and satellite units available.

APPENDIX C
INOCULUM SUPPLIERS

Judd Ringer Corporation
6860 Flying Cloud Drive
Eden Prairie, Minnesota 55344
Contact: Don Lovness (612) 941-4180

Cost: $1.30/lb. application: 1/2 lb./ton of leaves

NOTE: (They have 25 minute movie on leaf composting)

Turf Supply Co.
2970 Dodd Road
St. Paul, Minnesota
Contact: Jack Kolb (612) 454-3106
Milt Lindemann (612) 489-7914

Cost: $1.30/lb. application: 1/2 lb./ton of leaves

GENERAL INOCULUM COMPOSITION

6 enzymes to aid bacteriological decomposition.

15 - 25 fungus and bacteria decomposers and nitrogen fixers.

Sold in drums (dry).

APPENDIX D
MINNESOTA LEAF COMPOST PROJECTS

	Address	Hours
Hennepin County Leaf Recycling Bill Brenna (612) 935-3381 Maple Grove	Co. Rd. 109, 1 mi. west of Co. Rd. 18	8 - 6 daily
Eden Prairie	Franlow Rd., 1/2 mi. south of Co. Rd. 1	8 - 6 daily 10/13 to snow
City of St. Paul Leaf Recycling Seraph Sanchez (612) 292-6600 Maintenance Bureau (612) 298-4321	Victoria and Jefferson	10 - 6 daily 10/15 - 11/15
Village of Roseville Charles Honchell (612) 484-3371	Dale and Co. Rd. C	Sat. 10 - 4 Sun. 12 - 4 10/20 - 11/18
Fort Snelling National Cemetary Doyle Burdeshaw (612) 726-1127	Fort Snelling	Used for pre-dug graves to keep frost out.
Pelican Rapids Compost Site Ray Haugrud (218) 863-7655	Pelican Rapids	Call for hours
Fergus Falls Compost Site	Fergus Falls	Call for hours

FOOTNOTES

1 "County turns plant waste into resource: solves landfill, environmental pressures," *Rural and Urban Roads*, a Dun-Donnelley Publication, February 1973.
2 Personal communication with Stanley Bulpitt, Consultant, Brookside Nurseries, Darien, Connecticut
3 Personal communications with Hennepin County Sanitary Landfill, Woodlake Sanitary Landfill, and Flying Cloud Sanitary Landfill (all in Minnesota), plus *Solid Waste Management*, published by Communication Channels Inc. August, 1979, p. 12.

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