Basic On-Farm Composting Manual

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FINAL REPORT

Prepared for

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ON-FARM COMPOSTING MANUAL

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SECTION 1 - THE BASICS

WHAT IS COMPOST?

Compost is a nutrient rich soil-like material created by the biological decomposition of organic materials such as vegetative debris and livestock manures. Compost can improve soil fertility, extend fertilizers, save water, suppress plant diseases, and boost soil tilth. Composting manures can improve manure handling and help to reduce their environmental impacts.

WHY COMPOST?

Because farming itself involves the efficient management of a variety of natural processes, in many ways, composting is a natural fit for the farmer. Composting is the efficient management of the biological decomposition of organic matter. Ideally, the basics required for compost are readily available on the farm: **feedstocks** to be composted, such as livestock manure or crop residues; readily available **bulking materials** to thicken feedstocks**,** such as sawdust; and air, water, space and time. Microorganisms already present in the feedstock break down the material to a stable, beneficial product, free of pathogens and plant seeds.

On-farm composting requires some effort, but it can work for you.

HOW DOES IT WORK?

Composting is most commonly an **aerobic** process, that is, the biological breakdown of the materials takes place in the presence of oxygen (air). The main byproducts of the breakdown are carbon dioxide, water and heat. Composting can also be an **anaerobic** process, where breakdown occurs in the absence of oxygen. In this case, the main byproducts are methane, carbon dioxide, and various low organic acids and alcohols. Since aerobic composting is more efficient and presents fewer undesirable byproducts, this workshop will focus on aerobic composting.

The basic process of composting includes the following five steps:

- **Feedstock Preparation**
- **Composting**
- **Curing**
- **Screening**
- **Storage**

In a nutshell, feedstocks and any required bulking agents are mixed together in suitable proportions and spread into rows or piles. Air and water are added to the piles in appropriate amounts while the microorganisms in the mixed materials begin to eat and process the nutrients in the feedstock. This phase of composting, which is the most active, lasts about a month and generates temperatures high enough to kill pathogens and weed seeds. When this stage is complete, the compost may be moved to a separate pile and allowed to cure for an additional two months. While curing, biological activity in the compost is still taking place, but at a much slower pace than in the active phase. After curing, the compost may be screened to create a more uniform size, remove rocks and uncomposted materials, and to recover some types of bulking agents for reuse. The compost should then be **stable**, that is, it should have a fairly consistent look and an earthy, inoffensive odor. It can then be stored for use on the farm or put up for sale in bulk or bag.

That was the short version. These steps, plus the "nuts and bolts" of the machinery that can be used and information on rules and regulations, are explained in more detail in the following sections. Also, most of the "buzzwords" associated with composting, are defined in a detailed glossary which can be found in Appendix A.

HOW LONG DOES IT TAKE?

Your time investment: Composting will require time and effort on your part. Your biggest time investment will be the initial set-up of the composting facility, which will vary from farm to farm, depending upon the size of the facility you plan, the method of composting you choose, the site preparation work required, and the equipment available to you. Set-up time can range anywhere from a few weeks to several months.

Once your composting operation is up and running, typical time investment for a routine operation can range from **4 to 16** man-hours per week.

Nature's time investment: The time it takes from initial ingredient mixing through curing to the point of a stable product ranges from 60 to 120 days; **90 days** is a good rule of thumb. But since composting is a continuous process, beyond that initial 90 days or so, you should always have some compost ready for use.

HOW MUCH WILL IT COST ME?

The costs for setting up a composting operation will vary with your site, the size of your composting operation, the method of composting you choose, and the type of machinery you already have available. A typical cost range, assuming a composted volume of no more than 500 cubic yards per year, a small (30' x 80') site, use of the aerated static pile composting method discussed in this manual, and ownership of a front-end loader, is from $1000 to $1500. Detailed costs and materials for a somewhat larger on-farm set-up are shown in Appendix B.

HOW WILL I KNOW IF COMPOSTING CAN WORK FOR ME?

Composting is as much an art as it is a science. One learns to compost much the way one learns to farm - by doing. The fundamentals of composting are easy to grasp and implement, especially if a person discovers they have a true interest in the subject. Composting, as with farming, requires a spirit of trial and error to develop "know-how" and experience. While there are many wrong ways to compost, the "best way" to compost depends on many factors, including availability of land, equipment, and start-up capital.

Experience shows that small and medium sized composting trials are invaluable for developing this know-how while minimizing downside risks. Much can be learned by conducting small trials using various mixes of feedstock materials and composting techniques, during the different seasons of the year. A great deal can also be learned by visiting other composting facilities and talking with operators about their methods and experiences.

REFERENCES:

There are numerous references, parts of which have been incorporated into this document, that are readily available to the composter to assist him or her with operations start-up, process monitoring, marketing of the finished products, and virtually every other aspect of compost operation. The following selected references include periodicals, handbooks, engineering texts, and pertinent bodies of state and federal regulations:

- BioCycle, Journal of Waste Recycling, J.G. Press, Inc. 419 State Avenue, Emmaus, PA 18049 (215) 967-4135.

- On-Farm Composting Handbook, Northeast Regional Agricultural Engineering Service, NRAES-54, June, 1992, 152 Riley-Robb Hall, Cooperative Extension, Ithaca, NY 14853-5701, (607) 255-7654

- The Practical Handbook of Compost Engineering, Robert T. Haug, 1993, Lewis Publishers, CRC Press, Inc., 2000 Corporate Blvd., NW Boca Raton, FL 33431

- Minimum Functional Standards for Solid Waste Handling, WAC 173-304

- Standards for the Use or Disposal of Sewage Sludge, 40 CFR Part 503

- Interim Guidelines for Compost Quality, Washington State Department of Ecology Publication #94-38, April 1994.

SECTION 2 - BENEFITS OF ON-FARM COMPOSTING

This section discusses several of the benefits of composting, as well as some potential drawbacks to be considered .

SOIL CONDITIONING

Compost is an excellent soil conditioner. When applied to cropland, compost adds organic matter, improves moisture retention (drought tolerance) and soil structure, reduces fertilizer requirements and reduces the potential for soil erosion.

IMPROVED MANURE HANDLING

Composting reduces the weight, moisture content, odor, and **vector**-attracting qualities of manure and other farm generated organic waste materials. Compost is easier to handle than manure and stores well without odors or fly problems. Because of its storage qualities, compost can be applied at convenient times of the year.

IMPROVED LAND APPLICATION

Both compost and raw manure are good soil conditioners with some fertilizer value. However, there are benefits to be gained by composting manure.

- Composting converts the nitrogen contained in manure into a more stable organic form. Although this results in some loss of nitrogen, the nitrogen that remains is less susceptible to leaching and further ammonia losses.
- Highly bedded manures have a high carbon-to-nitrogen ratio, and when applied to the land directly, the excess carbon in the manure causes nitrogen in the soil to be temporarily unavailable to the crop. Composting high-carbon manure/bedding mixtures lowers the C : N ratio to acceptable levels for land application.
- The heat generated by the composting process reduces the number of weed seeds contained in the manure, resulting in a significant reduction of weeds over several years of application.

REDUCED WASTE DISPOSAL COSTS

Composting can reduce the volume of on-farm organic waste that may have previously gone to the landfill, thus avoiding a tip fee for those materials.

LOWER RISK OF POLLUTION AND NUISANCE COMPLAINTS

On a growing number of farms, manure is more of a liability than an asset. Disposal of manure is a problem where feed is not grown on the farm, when previously rented land is lost, or when herd size has increased beyond the farm's capacity to support it. Odor complaints are common in populated areas. Other concerns include runoff from manure spread in excessive amounts or on frozen ground, and nitrate contamination of wells and bodies of surface water. Composting can alleviate these problems.

PATHOGEN DESTRUCTION

Maintaining pile temperatures in excess of 55^{o}C (131^{o}F) for a period of 3-days will destroy pathogens that can be problematic for both humans and farm animal. The Aerated Static Pile (**ASP)** method of composting, discussed in Section 4, is capable of accomplishing this in a relatively short period of time because the 12 to 18-inch thick cover of finished compost material enables this temperature to be maintained throughout all of the newly composted material.

DISEASE SUPPRESSION

Properly prepared compost has been found to reduce soilborne plant diseases without the use of chemical controls. The disease suppressing qualities of compost are believed to result partly from a more complex and competitive environment of soil microorganisms.

BEDDING SUBSTITUTE FOR FARM ANIMALS

Compost has been used for poultry litter and bedding in livestock barns. Research and experience have shown that compost is generally a safe and effective bedding material.

SALEABLE PRODUCT

One of the most attractive features of composting is that there is a market for the product. Potential buyers include home gardeners, landscapers, vegetable farmers, turf growers, operators of golf courses, and ornamental crop growers. In addition, there are numerous applications in the construction industry. In this instance, a disposal problem has been converted into a revenue stream.

SOME OF THE DRAWBACKS...

In addition to the benefits of on-farm composting, there are several drawbacks which must also be considered, such as time and money, odor production, weather, marketing, and diversion of manure and crop residues from cropland.

TIME AND MONEY

Like any additional on-farm operation, composting requires equipment, labor, and management. The initial investment for a composting operation can be very low, if existing farm equipment and facilities are used. This approach is fine where the volume of material is relatively small (< 500 CY/year), but most medium (2000 - 4000 CY/year) to large (4000+ CY/year) scale farms have found that using only existing equipment requires too much labor. Many farm composters have found it necessary to purchase dedicated composting equipment. With special equipment, it could cost as little as $10,000 or well over $100,000 to start a farm composting operation, depending on the composting technology that is selected.

LAND

The area required for the composting site, storage for raw materials, and storage for the finished compost can occupy a considerable amount of land, and sometimes, building space.

ODOR

Composting operations inevitably produce some odor, and if the operation is mismanaged, the odors can be offensive and may generate complaints from nearby residents and passersby. That's why it's important to develop and maintain good neighbor relations with those in proximity to your composting site. This means maintaining an awareness of how odors from your operation impact others. A continual and conscientious effort toward odor control is essential for your composting operation to be successful.

Offensive odors can be minimized through proper process controls and good housekeeping procedures. In most cases, the odors from a well-managed composting operation are periodic and short-lived, and in cases such as manure handling, represent an improvement over conventional handling methods.

WEATHER

Cold weather may slow the composting process by lowering the temperature of the composting material. The effects of rain and snow are potentially more serious. Heavy precipitation adds water to the composting mix and can impede or stop the composting process altogether. Excessive rain can also create a serious leachate (contaminated water) handling problem.

MARKETING

Selling compost involves marketing, which means searching out potential buyers, advertising, packaging, managing inventory, matching the product to the customer desires, and maintaining consistent product quality.

DIVERSION OF MANURE AND CROP RESIDUES FROM CROPLAND

Selling farm-composted manure and/or crop residues diverts the nutrients, organic matter, and soil-building qualities of those materials from the cropland. Buying commercial fertilizers to make up for the lost nutrients may not make good economic or agronomic sense.

SECTION 3 - COMPOSTING OPERATIONS

The **five basic steps** to the composting process, as mentioned in the introduction, are now discussed in a bit more detail below.

STEP 1. FEEDSTOCK PREPARATION

Feedstocks (or organic materials to be composted) are mixed with bulking agents and/or feedstock amendments to provide a mixture suitable for composting

- **Bulking agents** are added to provide **porosity** and **structure** to the compost mix, and adjust the **moisture content** to within a desirable range, which helps create an environment in which the biological decomposition essential to composting can take place over time.

- Common bulking agents include: wood chips or shavings, sawdust, recycled compost, and shredded yard debris, all of which can be processed and stockpiled until needed.

- Some bulking agents, such as sawdust, become an integral part of the compost and cannot be separated out at the end of the process, while others, such as shredded tires, can be recovered and used again in the next batch.

- **Feedstock amendments** can provide a source of required nutrients, such as carbon. Some additives, such as wood chips, can act as both a bulking agent and an amendment, but each has a specific purpose and must be used appropriately.

- **"Recipe mixes"** or appropriate ratios of feedstock to bulking materials can be developed over time for your particular feedstocks. These mixes are determined by conducting a composting **mass balance evaluation** in which the carbon, nitrogen, and moisture content of each compost ingredient is evaluated, and the proportion of bulking or amendment material to reach the target **carbon-to-nitrogen (C:N) ratio** and moisture content is determined.

STEP 2. COMPOSTING

After the feedstock has been prepared, the mixture is formed into rows or piles, and composting can begin. Active composting generally occurs over a period of 21 to 28 days.
Composting represents the combined activity of a various bacteria, **actinomycetes**, and other fungi associated with a diverse succession of environments.

Moisture, temperature, pH, nutrient concentration and availability, and oxygen concentration are principal factors which affect the biology of composting. These factors are discussed below.

- **Moisture:** The optimum initial moisture content is 50% to 60% (total solids equals 100% minus the moisture content).

- **Temperature:** The majority of microorganisms associated with composting operate within one of two temperature ranges: the mid-range **(mesophilic)** from 50 - 105 ° F and the high-temperature **(thermophilic)** range from 105 - 160 +°F. Temperatures beyond 160°F cause most microorganisms to either die or become dormant which slows the composting process. These higher temperatures are also associated with generation of offensive odors. Thermophilic temperatures are most efficient and effective for composting. (Most weed seeds are destroyed at 145°F.)

Temperature must be carefully watched and adjusted as needed throughout the composting process. **Aeration,** discussed in Section 4, is the most effective way to maintain desirable temperatures.

During the winter months, suitable temperatures can be maintained by increasing the pile size and providing a cover of finished compost over the compost mix.

- **pH:** Although the pH varies throughout the pile and throughout the composting operation, the pH of the finished compost is generally within a range of 6.5 to 7.5. While the optimum pH range is 6.0 to 7.5 for bacteria and 5.5 to 8.0 for fungi, control of pH for optimum operation is difficult and is generally not attempted.

- **Nutrient Concentration:** Biodegradable carbon and nitrogen are required as energy sources. **Carbon-to-nitrogen (C:N)** ratios between 25 and 35 provide the best conditions. Lower **C:N** ratios increase the loss of ammonia by volatilization, and higher ratios lead to longer composting times. No other macronutrients or trace nutrients have been found to be impede the rate of composting.

- **Oxygen Supply:** An oxygen concentration of at least 5 percent by volume in the composting mix is generally required to ensure continuous aerobic conditions. However, increasing the oxygen concentration beyond 15 percent (by adding air) may result in a temperature, decrease because of the increased air flow. Therefore, temperature monitoring in conjunction with oxygen monitoring is recommended.

STEP 3. CURING

Following active composting, the processed materials are cured for a <u>minimum</u> of one month, and preferably, two or three months.

- The composting process continues throughout the curing phase, but at a slower rate and at lower temperatures. Curing creates a more stable compost and greatly reduces the potential for plant **phytotoxicity**.

- The moisture content of the compost mix during curing should be maintained at between 50 and 60 percent. Following the curing phase and prior to screening, the moisture content should be reduced to approximately 40 to 45 percent to facilitate **screening** and recovery of bulking materials.

STEP 4. SCREENING

- Screening of the materials is normally accomplished to produce the fine, uniform texture desired for the final product, and to recover the bulking material for reuse in the composting process. Screening is not necessary with certain (fine) bulking agents. Screening can be accomplished either before or after curing.

STEP 5. STORAGE

- Stable compost can be stored under cover for several months, without the risk of spoilage. Suitable storage is important because compost use typically peaks in the spring and fall months, moderates through the summer and virtually ceases in the winter.

- Stored compost should be kept dry, to maintain product quality and minimize potential surface water contamination. This can be accomplished by covering the compost with tarps or by storing it under a roofed structure.

SECTION 4 - METHODS OF COMPOSTING

One method of composting will probably suit your circumstances better than another. The following three technologies seem to work best for on-farm composting:

- **Turned Windrow**
- **Aerated Static Pile (Individual)**
- **Aerated Static Pile (Extended)**

These technologies are described below, followed by a discussion of some of the advantages and disadvantages of each.

TURNED WINDROW COMPOSTING

With the turned windrow composting process, the mixture to be composted is stacked in long parallel rows separated by alley-ways for equipment access. The cross-section of the windrows may be trapezoidal or triangular, depending largely on the characteristics of the equipment used for turning the piles. The width of a typical windrow ranges between 8 and 18 feet, and the height ranges between 4 and 7 feet.

Compost windrows may be turned with conventional front end loaders or with specialized windrow turning equipment. When relying on front end loaders for windrow turning, this technology is best suited to small facilities. It is not well suited for medium and large quantity generators.

The windrow process is generally conducted in uncovered areas and relies on natural ventilation with frequent mechanical mixing of the piles to maintain aerobic conditions. Some biosolids composting facilities have invested in a structural roof or enclosed building, to control moisture and temperature conditions and to manage odors. A typical windrow composting layout is shown in Figure 4-1.

Advantages And Disadvantages:

Advantages of the windrow composting process include thorough mixing of materials, wide selection of windrow turners at competitive prices, and mechanical breakdown of larger bulking materials that will not be recovered for reuse. In addition, there is long term experience with full scale operation in the U.S.

The primary disadvantage to a windrow system is a comparatively large land area requirement resulting from both the physical configuration of the process and from the longer times required for composting to meet federal requirements such as a “Process to Further Reduce Pathogens” (**PFRP)**. Because of the extended time required for composting, the energy in the system (the nutrients needed for maintaining **thermophilic** conditions) may be depleted prior to meeting **PFRP** conditions.

Another disadvantage is that there is a greater risk of odor production, particularly when windrows are turned during periods of calm air and temperature inversion. Lastly, because excessive moisture can significantly slow down the composting process, windrow composting in rainy climates can be problematic, and may require the installation of a structural roof.

AERATED STATIC PILE COMPOSTING (INDIVIDUAL AND EXTENDED)

The **aerated static pile (ASP)** method of composting was developed in the mid-1970's to reduce land area requirements and to resolve other problems associated with the windrow composting process. The **ASP** method of composting consists of the following steps:

- Mixing feedstock materials
- Construction of the composting pile
- Active composting (with positive and/or negative aeration)
- Drying (with positive aeration)
- Screening (to separate the finished product from recycled bulking material)
- Curing (with positive aeration)
- Storing and distributing the finished product

Two distinct aerated static pile methods have been developed and include the individual **ASP** and the extended **ASP** methods.

Individual Asp Method

With the individual **ASP** method, the compost mix is constructed over perforated plastic pipe, oriented longitudinally along the centerline of the pile. Air is forced (positive aeration) or drawn (negative aeration) into the pile using an electric blower. To avoid short circuiting of the air flow, the perforated section of pipe is placed within the core area of the pile, and connected to a section of solid pipe that extends beyond the ends of the pile at the base. The solid pipe is used to connect the perforated pipe to the blower.

Prior to constructing the pile of mixed materials, the pipe is placed on the **compost pad** and covered with an 8- to 12-inch layer of coarse bulking material, which serves as the aeration plenum. This base has a high porosity which facilitates the movement and distribution of air up through the compost mix and absorbs the excess moisture that may otherwise drain from the pile.

A **front-end loader** or portable mixer is commonly used to prepare and blend the feedstock materials prior to constructing the pile. The resulting mixture is placed loosely over the prepared base by a front-end loader. The pile is constructed with a “triangular” cross section, with approximately 1:1 (horizontal : vertical) side slopes.

The pile is then completely covered with a layer of screened or unscreened finished compost, at least 12 inches in thickness. The outer cover of compost provides insulation for the newly mixed materials. **PFRP** conditions are met when the pile temperature equals or exceeds 55 °C (131 ° F) for a minimum period of 3 days.

In the positive aeration mode, the finished compost cover serves as a biofilter and reduces the escape of odorous gases during composting. In the negative mode, air that is drawn through the pile can be discharged through a biofilter consisting of finished compost, bark dust, and combinations of other organic and non-organic materials.

With **ASP** composting, aerobic composting conditions are usually maintained by inducing a flow of air intermittently through the pile of mixed feedstock materials.   The aeration rate must be adjusted to maintain desired oxygen levels and temperatures. If the aeration rate is too high or the blower remains on too long, the pile will cool, and the **thermophilic** decomposition process will be inhibited.

A process schematic of the individual **ASP** method of composting is shown on Figure 4-2.

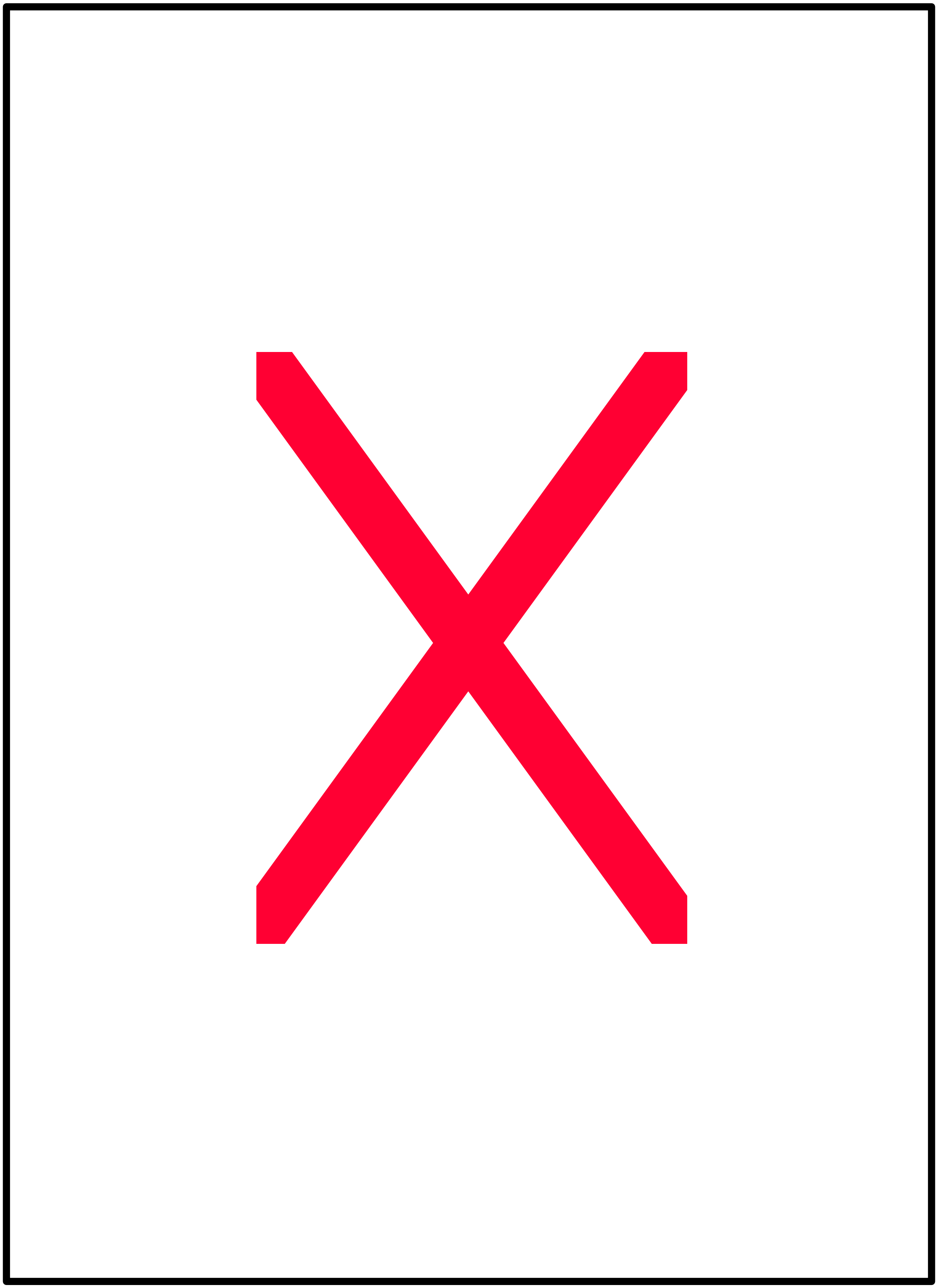
Extended Aerated Static Pile

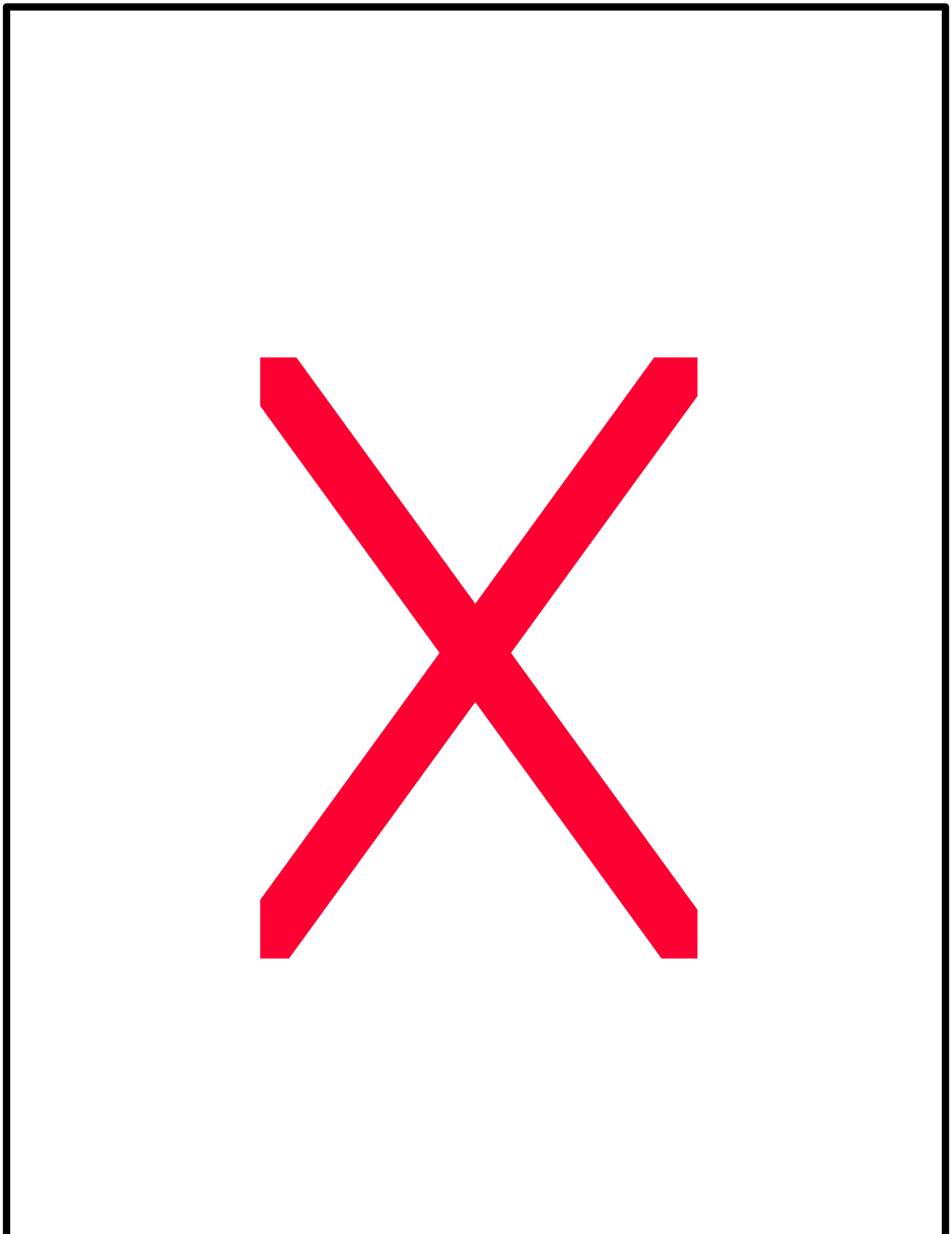
To make more effective use of available space, another **ASP** configuration called the extended aerated static pile has been developed. An individual pile (cell) is constructed, as discussed previously, with a triangular cross section. The back side and the ends of this first cell are blanketed with a 1-foot thick blanket of finished compost, and the facing or advancing side is dusted with 1 to 2 inches of compost for overnight odor control.

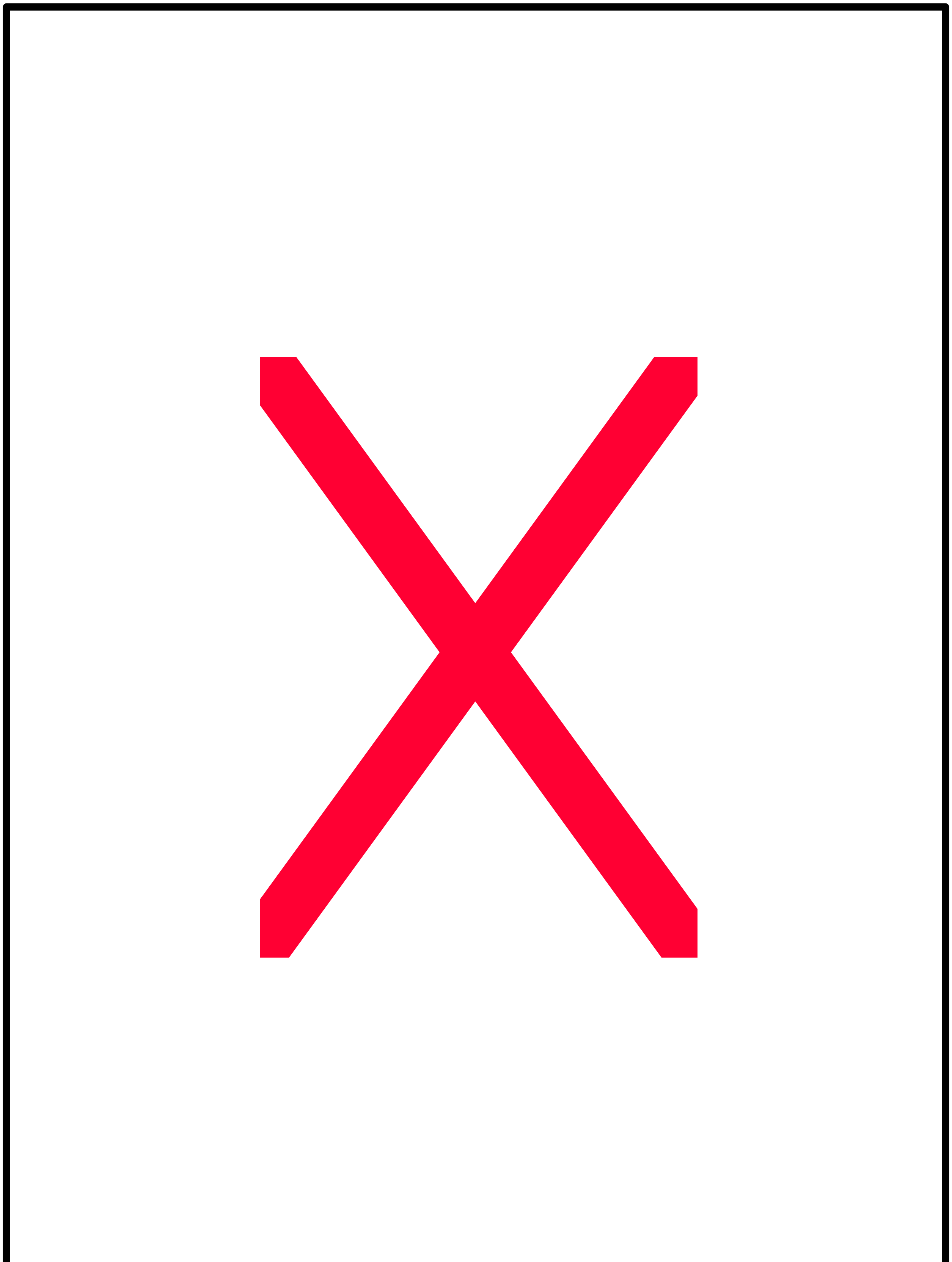
Adjoining cells are constructed by placing aeration pipes on the pad parallel to the dusted side of the initial cell. The aeration plenum is extended by covering the newly placed perforated pipes with more bulking agent, and then the next cell of feedstock mixture is constructed with a trapezoidal cross section (horizontal top and bottom, and 1:1 side slopes). This process is repeated daily for a period of approximately 4-weeks, thereby forming an "extended" pile.

At the end of active composting, the cells are broken down sequentially in the same order that they were constructed, and the compost is removed from the pad for screening and curing. After six to eight cells have been removed, there is sufficient space on the pad for operating equipment to construct a new extended pile. This process is repeated continuously in a wave-like manner across the site.

The area requirements of an extended pile system are about 25 to 50 percent less than that for individual piles. The amount of recycled bulking agent required for covering the pile is similarly reduced.







A typical layout of an extended **ASP** method of composting is shown on Figure 4-3.

Advantages and Disadvantages:

The **ASP** method provides for more flexible operation and more precise control of oxygen and temperature conditions in the pile than would be obtained in a windrow system. Since the time required for composting tends to be slightly shorter and anaerobic conditions can be more readily prevented, the risk of excessive odor generation can be reduced. In addition, aeration in the negative mode can enable collection of odorous off-gases for treatment in a biofilter.

Currently, much of the interest in composting of wastewater biosolids is centered on the ASP technique. Advantages include lower capital and operating costs, superior odor control, greater inactivation of pathogenic organisms, and use of less site area. With use of the insulative cover, the **ASP** technique exposes all biosolids to more uniform temperature, and for this reason **PFRP** conditions may be met over a significantly shorter period of time, with decreased labor and equipment time.

In summary, some of the advantages of the ASP system include:

- Good process and odor control.
- Lower capital cost than other systems.
- Flexibility to handle changes in feedstock quantity and quality.
- Easily expandable to handle increase in feedstock production.
- Established technology commonly used in the US

Some of the disadvantages of a static pile system include:

- No agitation of pile contents during composting, which could adversely impact process stability, especially with co-composting of yard wastes.

- Decreased ability to adjust moisture in composting mass after initial mix, and a potential for drying in the immediate vicinity of the aeration system, particularly when operating in the positive (forced) aeration mode.

- Condensate collection and disposal required in the negative aeration mode.

SUMMARY OF COMPOSTING PROCESSES

The three composting technologies discussed have been evaluated using selected screening criteria. This evaluation is summarized in a comparison matrix, presented as Table 4-1. The general screening criteria include technology level, cost, environmental factors, full scale operating experience, and operations. The general criteria have been subdivided into specific criteria, and each has been evaluated on the basis of observations made at existing compost facilities and information provided by facility operators.

ON-FARM COMPOSTING TECHNOLOGY COMPARISON MATRIX

CRITERIA	Windrow	Aerated Static Pile (Individual)	Aerated Static Pile (Extended)
Technology Level	Moderate	Moderate	Moderate
Cost			
Capital Cost	Moderate	Moderate	Moderate
O&M Cost	Moderate	Moderate	Moderate
Environmental Factors			
Odor Potential	Moderate - High	Low - Moderate	Low - Moderate
SW/GW Control Req'ts	High	Low - Moderate	Low - Moderate(1)
Weather Impacts	High	Moderate	Moderate
Visual Impact	Low	Low	Low
Regulator Compliance	High	High	High
Full Scale Operating Experience			
Proven Usage	High	High	High
Operations History	Mixed success	Good	Good
Reliability	High	High	High
Operation			
Space Requirements	High	Moderate	Low
Maintenance Reqs.	Moderate	Low	Low
Operational Controls	Moderate	Moderate - High	Moderate - High
Operational Complexity	Moderate	Moderate	Moderate
Flexib. for Bulking Mtls	High	Moderate	Moderate
Product Quality	Moderate - High	High	High

SECTION 5 - COMPOSTING EQUIPMENT

Materials handling equipment is necessary to transport and process agricultural waste materials, bulking agents, initial mixtures, and finished compost at on-farm composting facilities. Materials handling equipment can be segregated into portable and stationary categories. Portable equipment used for material handling includes:

- **Front-end loaders (FEL)**
- **Grinders and Shredders**
- **Mobile Mixers / Manure Spreaders**
- **Windrow Turners**

Stationary equipment used for materials handling at composting facilities includes:

- **Conveyors**
- **Screens**

Generally, a combination of portable and stationary equipment is necessary for any composting facility. The suitability of one type of equipment versus another is based on many factors, including facility size, material through-put requirements, space constraints, capital and O&M costs, and operator preference. In general, as a composting system becomes more mechanized, it also becomes less portable.

The most significant problems with mechanized composting facilities are the lack of operational flexibility and/or the misapplication of materials handling equipment. Portable equipment can generally be replaced on a temporary basis if maintenance or mechanical problems arise.

Stationary equipment, on the other hand, must be serviced and repaired in-line. Failure of this equipment can cause considerable disruption to the necessary flow of materials. Therefore, a certain amount of redundancy is warranted, despite the resulting increase in overall capital cost of the facility.

FRONT END LOADERS

The **front end loader (FEL)** is an essential piece of equipment at all compost facilities. The **FEL** is used for transporting, stockpiling and loading raw materials and finished compost products, with the ultimate purpose of facilitating the flow of materials through the compost facility.

FEL's are available in many sizes, each designed to meet specific ranges of load capacity for lifting and transporting rock, sand, gravel and soil. These materials typically have unit weights which are between two or three times that of compost materials. For this reason, many compost facilities utilize oversized loader buckets to optimize cycle time per cubic yard of materials handled. The selection of an appropriate **FEL** is also based on numerous standard and optional features which are matched to the intended use of the equipment.

Most farms have one or more front end loaders, and if adequately sized (i.e., two cubic yard buckets), these can be used for most compost applications.

GRINDERS AND SHREDDERS

Most raw materials used for farm composting do not require grinding or shredding, especially if a windrow turner is used. Several raw materials that benefit from shredding include newspaper, corrugated cardboard, brush, and other yard waste. The primary types of grinding/shredding equipment used for composting systems are shear shredders, hammer mills, tub grinders, and chippers.

Most shear shredders use two counter-rotating shafts with overlapping hooked cutter discs. Cutters draw material down toward shafts at the base of a hopper. The cutters slice or tear the particles into smaller pieces until they pass through the spaces between the cutter discs. The size of the sheared particles is determined by the cutter disc size. Counter-rotating augers are also used to accomplish the material size reduction on some machines.

Material dropped into a hammer mill is size-reduced by free-swinging metal hammers mounted on a spinning shaft. The hammers break apart material until it is small enough to drop through discharge screens. Hammer mills can be very large and are typically stationary. They tend to create more noise than shear shredders because of their pounding action.

A tub grinder is a type of hammer mill that uses a rotating tub intake system to crush wood and brush. The rotation moves materials across a fixed floor, which contains the hammers. As material is ground, it is forced through a screen or other restricted opening and then conveyed into standing piles or into a transfer vehicle via stacking conveyor. Tub grinders are typically loaded by an **FEL**.

Chippers slice particles with knives mounted on a cylinder or disc that rotates within a fixed housing. Forage harvesters have been tried for shredding paper and cardboard with limited success.

In all cases, shredding and grinding equipment requires a considerable amount of routine maintenance and repairs. Unless a farm also is prepared to compost imported organic waste materials such as yard debris, wherein tipping fees would be received, purchasing expensive shredding and grind equipment is not advisable. This equipment is readily available on a lease or contract basis. A contract is preferred, particularly where materials can be accumulated and processed on a batch basis.

MANURE SPREADERS

Proper mixing of the feedstock materials is of critical importance in the composting process to ensure uniform conditions throughout the compost pile and to minimize the potential of developing **anaerobic** zones and offensive odors.

In general, feedstock mixing can be conducted with front end loaders. However, the use of manure spreaders or specialized mixing equipment in conjunction with an **FEL** is preferred where composting operations require mixing wet waste materials with comparatively dry bulking agents.

In many applications, manure spreaders have proven to be adequate in mixing initial feedstock materials, however some premixing with an FEL is required. The advantage of using a manure spreader in mixing the feedstocks is that many farms have this equipment already, thereby off-setting a significant capital expenditure for specialized mixing equipment. A manure spreader will not be as well suited to mixing relatively dry feedstock materials.

MIXERS

Specialized mixing equipment is divided into two general categories: batch mixers and continuous or flow-through mixers. Batch mixers operate by receiving measured volumes of feedstock materials (wet manure and bulking agent) in accordance with a prescribed mix ratio. The feedstock materials are then blended for a period of 2 to 4 minutes by a system of counter rotating augers, shafts and paddles, or rotating blades. After being thoroughly blended, the initial mix is discharged out the back or side of the mixer with a drag chain conveyor, belt conveyor or system of augers.

Continuous mixers rely on a uniform, metered flow of feedstock materials. The feedstock materials enter the equipment at the upstream end, advance through the machine as part of the mixing action, and are discharged at the downstream end either into a pile or onto a conveying system that transfers the initial mix directly to the active composting area. Continuous mixers typically result in a higher initial capital cost, although this additional cost can be offset by decreased labor and increased efficiency in large volume facilities.

Continuous mixers generally come in three basic varieties: pug mills, plow blenders and screw conveyors. Pug mills and plow blenders are similar in construction materials, safety features, and operation and maintenance features. They differ in that pug mills use rotating shafts with paddles that tend to shear the feedstock materials and plow blenders use rotating shafts with plow-shaped blending elements that tend to lift and roll the materials. Both methods can be highly effective at mixing a wide range of materials.

WINDROW TURNERS

For small to moderate operations, turning can be accomplished with a front end loader. The loader simply lifts the materials from the windrow and spills them down again, mixing the materials and reforming the mixture into a loose windrow. The loader can exchange material from the bottom of the windrow with material on the top by forming a new windrow next to the old one. This needs to be done without driving onto the windrow in order to minimize compaction. Windrows turned with a loader are often constructed in closely spaced pairs and then combined after some composting has taken place and the windrows have shrunk in size.

Turning windrows with a front end loader is typically slow and therefore equipment and labor intensive. Additionally, this method of turning is not as effective at mixing materials and does not mechanically break down the material constituents.

A number of specialized machines have been developed for turning windrows which greatly reduce the time and labor involved. Though they represent a significant capital investment in single-application equipment, specialized windrow turners have the ability to mix the materials more thoroughly, mechanically break down the compost constituents, and produce a more uniform compost than a front end loader.

Some of these machines are designed to attach to farm tractors or front-end loaders while others are self propelled. Windrow turners fall into three basic categories:

- Tractor assisted rotary drum with flails
- Tractor assisted or self propelled elevating face conveyor
- Straddle-type, self propelled, rotary drum with flails.

The cross sectional dimension of a windrow is dependent upon the dimensions and configuration of each windrow turner. Some machines are designed to turn the windrow in two passes (one on each side) while others are designed for single pass operation. In all cases, alley-ways between windrows must be maintained for access purposes, and for this reason, the composting area may be significantly greater than for alternative composting technologies (i.e., extended **ASP** composting). With windrow composting, air is entrained at the time of turning, however, the oxygen supply is quickly used up by the microbes and the windrow returns to an anaerobic condition within 30 to 60 minutes. Windrow turners also release a considerable amount of steam and odorous gases which may be offensive to local residents.

SCREENING EQUIPMENT

Screening of the compost achieves two objectives: 1) recovery of a portion of the bulking material for reuse and 2) preparation of a uniform, marketable finished product. The mesh size can be selected to meet both of these objectives. Trial and error is generally required to match mesh size to the consistency and moisture content of the infeed materials. A 1/4 - 1/2 inch mesh has been found to work quite well in most applications, however, larger and smaller sets of screen meshes should be kept on hand to optimize production rates. If too small a mesh is used, the efficiency of the screening system will be reduced, possibly necessitating rescreening of the oversized materials.

There are two types of screens used in composting, including trommel screens and vibratory deck screens. In most applications, trommel screens have been found to be superior in performance and generally require less maintenance. They can be sized to accommodate the projected volume of materials, and typically range from 5 to 8 feet in diameter and from 12 to 30 feet in length. The diameter determines the amount of surface area to which the compost is exposed, and the length and inclination of the screen determines the detention time within the screen.

STACKING CONVEYORS

Stacking conveyors will be needed at several of the process areas of the composting facility, including the mixing area, screening area and the product storage area. The types of conveying equipment most appropriate for each material varies with the anticipated material properties, such as whether it is:

- uniform or variable
- dry and dusty
- wet with free water
- sticky or cohesive, or
- flowable,

Conveying equipment commonly used at composting facilities includes the following:

- flat belt conveyors
- cleated corrugated sidewall conveyors
- screw conveyors
- drag chain conveyors, and
- bucket conveyors.

Flat belt conveyors, the most common type of conveyor, are generally recommended for use on farms. They are well suited to conveying any of the materials found in a farm composting facility. The advantages of belt conveyors are that they are readily available, relatively inexpensive, easy to maintain, and can be fixed or portable. Some disadvantages include that they are limited to straight runs and to inclines of no more than 15 degrees from the horizontal.

Normally, belt conveyors are installed in a 35 degree troughing configuration, with the conveyed material confined by skirts. An end discharge arrangement allows the use of a scraper assembly for belt cleaning.

Radial stacking conveyors can also be used to create a larger, crescent shaped stockpile of finished compost materials. In the event that these materials are to be stored on-site for a considerable length of time, it may be advantageous to move the stockpile to aerate and/or cool the materials. This can be easily accomplished with a radial stacking conveyor in combination with one or two front end loaders.

SECTION 6 - SITE AND ENVIRONMENTAL CONSIDERATIONS

There is ever increasing pressure on the farmer to reduce impacts to the environment from what have long been considered traditional methods of farming. In part, this is the result of a more stringent regulatory environment. It also results from more intensive farming methods combined with a decrease in land base. The primary areas of concern include the following:

- Surface Water Contamination - Runoff
- Ground Water Contamination - Infiltration
- Nitrate Build-up in Agricultural Soil
- Legal and Cost Effective Alternatives for Organic Waste Disposal (Utilization)

REGULATORY COMPLIANCE ISSUES

Permits for on-farm composting operations are generally not required for small to medium size facilities that don't sell finished compost products on a wholesale or retail basis (refer to Section 9). Nevertheless, a well-run facility must operated in compliance with the state and local regulations pertaining to surface water, ground water and odors. Negligence in any or all of these areas will likely result in an order to mitigate the problem(s), as well as ensure the attention of the jurisdictional health district from that time forward.

SITING AN ON-FARM COMPOSTING FACILITY

A site for an agricultural composting facility must provide the required area and conditions for all-weather composting as well as limit the environmental risk associated with odor, noise, dust, leaching, and surface water runoff. Site planning involves finding an acceptable location, adapting the composting method to the site, providing sufficient land area, and implementing surface water runoff and pollution control measures as needed. The materials being composted and system management will also impact these environmental concerns.

In addition to the site regulatory requirements that may apply, it is important to be aware that starting a composting facility may raise concerns among neighbors and local public officials. Educating these groups about composting and its advantages will be a critical part of getting started smoothly. It is essential to include concerned individuals in the planning process from the beginning to develop a "good-neighbor" working relationship.

The location of the composting site should allow easy access, a minimum of travel and materials handling, and a firm surface to support vehicles under varying weather conditions. Usually the most convenient composting site on the farm is near the barn or manure storage facility. However the convenience of a particular site must be weighed against factors such as area, proximity to neighbors, visibility, drainage, and runoff control. The best site on the farm may not be the most convenient; or a convenient site may require modifications such as grading or drainage.

Odor is the single greatest reason for composting facilities to be shut down. Sites near sensitive locations, such as schools, hospitals, and nursing homes, should be avoided. Odors from the composting process are minimized through good management only if the composting system is properly designed and laid out. In siting the facility, consider the direction of prevailing winds during warm periods (open windows and outdoor activities) and cold periods (thermal inversions). Turning windrows should be avoided during high impact weather conditions.

Consideration must also be given to the noise and dust resulting from the composting operations and from transport vehicles traveling to and from the site. This can be addressed somewhat by selective scheduling of activities during the day.

Site visibility and appearance influence human perceptions. Fewer neighborhood complaints will be received if the composting site is less visible. To shield the composting site from public view, take advantage of natural landscape features such as topography and natural or planted vegetation. Good housekeeping is not only prudent from an operational standpoint, but is also of critical importance in developing good relations with neighbors and regulators.

SEPARATION DISTANCES

The separation distance, or buffer zone, between the farm composting operation and streams, water resources, and nearby human housing is intended to address water quality concerns and the nuisance factors of odor, dust and equipment noise.

The <u>On-Farm Composting Handbook</u> recommends the following minimum separation distances:

Sensitive Area	**Minimum Distance (feet)**
• Property Line	50 - 100
• Residence or Place of Business	200 - 500
• Private well or other potable water source	100 - 200
• Wetlands or surface water (streams, ponds, lakes)	100 - 200
• Water table (seasonal high)	2 - 5 (vertical)

DRAINAGE REQUIREMENTS

Good drainage at composting sites is critical. Poor site drainage leads to ponding of water, saturated composting materials, muddy site conditions, and excessive runoff and leachate from the site.

In areas of high precipitation, composting operations should be conducted on an impervious surface, such as concrete or asphalt, or under cover to provide all-weather access to composting equipment and to avoid contamination of the finished compost with soil and rocks. An impervious surface also serves to protect infiltration of compost leachate and prevent contamination of the ground water.

The site should be graded to direct surface water runoff to one or more collection points (e.g., catch basins, manure lagoons, retention ponds). The collected runoff can be directed to pasture, cropland, or retained for future beneficial use. Run-on water, or the surface water from surrounding land that drains onto the site should be diverted away from the composting pad and storage areas. This can be accomplished by using diversion ditches, interceptor drains, or berms. Buildings should have roof gutters or perimeter drains if the roof runoff would otherwise empty onto the site.

SECTION 7 - COMPOST QUALITY

Compost quality is measured by several criteria, including the following:

- **Moisture content**
- **Nutrient content**
- **Particle size distribution**
- **Stability**
- **Content of other elements (e.g. heavy metals)**
- **Product consistency over time**
- **Pathogen levels**

MOISTURE CONTENT

The moisture content of the compost product is controlled by storing the product so as to avoid significant moisture addition by rainfall. The product must be dry enough to allow hauling with conventional loading, hauling, and spreading equipment / methods. The 45 percent moisture content criterion for efficient screening also provides a dry enough product to meet these needs. Care must also be taken not to over-dry the product as well. When compost is too dry, it will generate dust when handled, and dry compost can be difficult to re-wet.

NUTRIENT CONTENT

The nutrient content of compost is also a quality component. The major plant nutrients supplied by compost are nitrogen, phosphorus, and potassium. Most minor plant nutrients are also contained in compost and these also contribute to its quality. The level of nutrients in compost is controlled by the chemical composition of the material. While not a fertilizer, compost is often used as a fertilizer supplement.

PARTICLE SIZE DISTRIBUTION

This quality parameter is primarily a function of the screen size used. Different end-users of compost will have different requirements for particle size distribution of the compost. The most demanding user in this regard will be horticulturists that will use the material in potting mixtures. The specifications for particle size distribution requirements can be ascertained from users. Those who will use the compost to amend field soils (e.g., landscapers, orchardists, field crop growers) will have less stringent requirements, but still should be provided samples of the product to test prior to deciding on an appropriate particle size specification.

STABILITY

The term "stability" as used here means a product that will not undergo rapid decomposition or produce nuisance odors when applied by users. If the compost has undergone the adequate composting and curing procedures, there should be no problem in achieving a stable product. Assuring a minimum curing period of 30 days is important to producing a stable compost product.

CONTENT OF OTHER ELEMENTS

The content of undesirable elements in compost, such as heavy metals, (e.g. cadmium, copper, zinc, lead, mercury, nickel, and chromium) is generally at very low levels in yard debris and the final compost product. Weed seeds are controlled by maintaining temperatures suitable to meet **PFRP** requirements.

PRODUCT CONSISTENCY OVER TIME

This quality parameter is one of the most important to users. In order to incorporate compost into their operating practices, users must be certain that each batch of materials has the same properties, within relatively narrow limits. Inconsistency in product quality will result in reduced consumer confidence and will jeopardize future marketing efforts.

PATHOGEN REDUCTION CRITERIA

Agricultural waste compost is not required by regulation to comply with the pathogen reduction criteria that is stipulated for municipal sludge (biosolids) compost. However it is good practice and may be required if a site permit is required for non-farm organic waste material. The compost product should fulfill the following criteria:

- The compost product should be brought to a minimum temperature of 131^{o}F (55^{o}C) for three consecutive days for ASP (or 15 days with 5 turns for turned windrow) in order to fulfill the requirements of a biosolids stabilization process to further reduce pathogens (**PFRP**).

- In addition to **PFRP** stabilization, these elevated temperatures are effective at killing weed seeds, which is a very important product quality concern.

- The compost product should be exposed to a minimum composting period of 42 calendar days and a minimum curing period of 30 calendar days prior to distribution.

- Monitoring of the compost product for pH, percent total solids, volatile solids reduction, nutrients, and heavy metals concentration should be done on a regular basis.

SECTION 8 - MARKETING AGRICULTURAL COMPOST

If you choose to go to the effort of selling the compost in addition to or instead of applying it on your own land, you will need to develop a market for the finished product. One of the main tasks in marketing farm-produced compost is to carve out a niche which emphasizes the difference between agricultural compost and other municipal or industrial waste-derived compost products. Farm-produced compost occupies a high quality position in the market. Your marketing efforts should take advantage of this position and help to maintain it. This means that the highest priority must be placed on quality control, as discussed previously.

Potential buyers of compost include landscapers, commercial nurseries, home and garden centers, greenhouses, homeowners, organic farmers, golf courses, cemeteries, public works departments, road and highway contractors, schools, parks departments, turf growers, and developers. All of these groups use compost or some other product that compost can replace, including peat moss, topsoil, and (to a limited extent) chemical fertilizer.

Once the potential buyers have been identified, the next step is to determine how large the market is for the compost. In most cases, the market for the compost is very local, within 25 to 50 miles of the composting facility, because the cost of transportation is high compared to other production costs. Although transportation restricts the market area, it also limits competition.

Within the local area, the potential buyers of compost products should be surveyed to determine whether they would purchase compost, how much they might be willing to pay, how and when they would use it, desired characteristics or specifications for the finished products, etc. A simple survey conducted by mail, telephone or in person is necessary to understand the needs of the end users.

From this information, target markets should be identified, and selected individuals should be given small bulk quantities for growth trials and demonstration purposes. Meeting the needs of the target market(s) may dictate a change in your processing system or possibly even re-evaluating desired target markets. **Designing the composting process to meet the market specifications is critical to the long term success of your venture.**

Offering a variety of compost products may increase your success at developing a target market. For instance, in addition to a premium compost product, you may offer a compost mulch (screen overs) and a topsoil mix. It is important to keep in mind that as a compost material ages, it also becomes a more stable product and therefore a better product.

Key factors in marketing a finished compost product include the following:

- **<u>Color / texture / odor</u>:** Users expect compost to be uniform in texture, relatively dry, dark brown or black in color, and to have an earthy (non-offensive) odor.

- **<u>Reliable supply</u>:** Customers, especially businesses and municipalities, expect a reliable supply, especially if they have been given a commitment.

- **Price:** The price must be generally competitive with other composts and compost substitutes, and the price should not vary significantly over time. Discount incentives may be offered for large quantity orders, however the discount should only become effective after purchase of an established minimum quantity within a defined period of time. Price quotes for contractors should be honored after bid award.

- **Reputation: Everything! Reputation for excellent quality and reliability is paramount to the long term success of marketing your composted materials.**

SECTION 9 - REGULATORY APPROVALS AND PERMITS

In the state of Washington, permits are generally not required for on-farm composting and utilization. Some, but not all, counties require a solid waste handling permit if finished products are sold on a wholesale or retail basis. All counties require a permit if yard debris (municipal solid waste) is included as a feedstock and/or if volumes of processed materials become so large as to require environmental safe guards and process monitoring. The volume threshold is determined by each Jurisdictional Health Department (JHD).

Before you begin a composting operation, contact your local health department to determine their permitting requirements for a new composting facility. Be prepared to provide the following information during this first discussion:

- Type and quantity of materials to be composted
- Location of composting facility (proximity to neighbors and surface water)
- Intended use of compost

APPENDIX A - GLOSSARY OF COMPOSTING TERMS

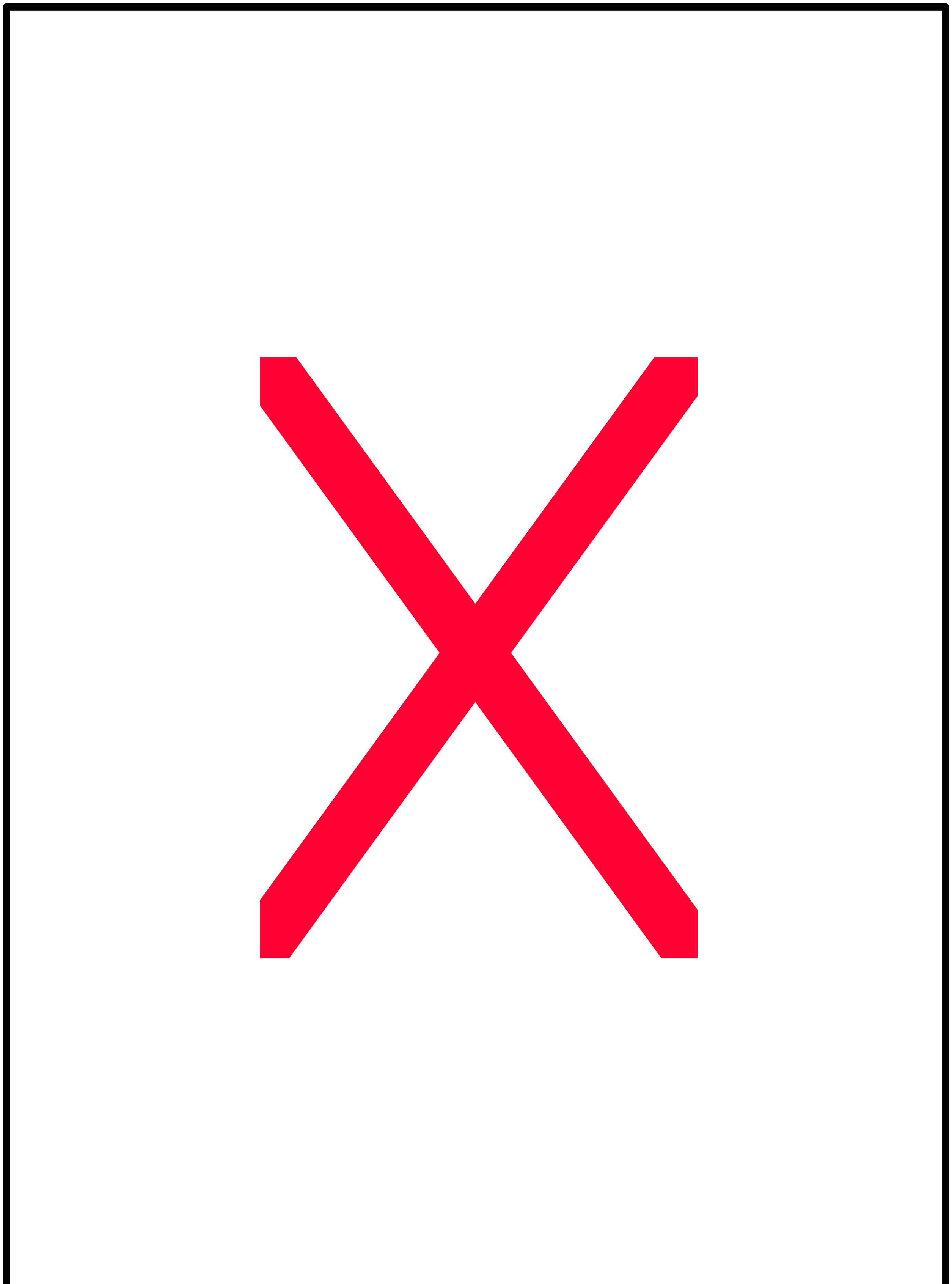
AERATION	Providing air and oxygen to the composting piles either through turning or ventilation (by blowers) to aid the microorganisms in breaking down of the material into compost. Aeration can be in the positive (forced; push) mode or in the negative (induced ; pull) mode.
AEROBIC	Aerobic composting is the decomposition of organic substrates in the presence of oxygen (air). The main products of biological metabolism are carbon dioxide, water and heat.
ANAEROBIC	Anaerobic composting is the biological decomposition of organic substrates in the absence of oxygen. Metabolic end products of anaerobic decomposition are methane, carbon dioxide, and numerous low molecular weight intermediates such as organic acids and alcohols.
BERM	Barrier adjacent to a facility to shield or deflect noise and water from the facility. A berm sometimes serves as a screening barrier.
BIODEGRADATION	The biological decomposition or breakdown of organic matter by microorganisms. During this process, microbial energy in the form of heat is produced. This energy can be used to kill pathogens, destroy weed seeds, and evaporate water. Organic matter is turned into a stable humus or compost through this process.
BIOFILTER	A designed pile consisting of finished compost, bark and similar stable organic materials used for biologically stripping odor producing compounds from composting off-gases. Biofilters are used with aerated static pile composting, when operating in the negative mode.
BUFFER ZONE	Area between the composting facility and homes or other sensitive land uses that shields these neighboring uses from impacts of the operation. A buffer zone that is vegetated can contribute to visual screening and noise interception.
BULKING AGENT	Relatively large particle (size) materials, such as wood chips that create air space to accelerate the composting process.

COMPOST	The stabilized material resulting from the composting process. Finished or stabilized compost is a humus (earth-like) organic material. Depending on the material composted, the compost may have some nutrient value and is often used as a soil conditioner.
COMPOST CLASSIFICATION	Compost is classified into fresh, mature, or cured compost, depending on its level of stabilization.
COMPOST GRADE	Compost is graded into fine, medium, and coarse compost according to its physical and chemical characteristics.
COMPOSTING	Composting is the biological decomposition and stabilization of organic substrates under conditions that allow thermophilic temperatures as a result of biologically produced heat, to produce a final product that is stable, free of pathogens and plant seeds, and can be beneficially applied to land (Haug, 1993).
COMPOST PAD	An area within the composting site where organic materials are processed. If not a hard surface, the pad should be constructed of material that drains well and will support heavy equipment in all weather conditions.
COMPOST TURNING MACHINE	A vehicle fitted with a device to turn the windrows of composting material to fluff the material, thoroughly mix it, and provide air to the piles.
CURING	The final stage of compost to further stabilize the composted material.
DECOMPOSITION	The process of breaking down dead organic material, such as fallen leaves, by microorganisms.
FRONT-END LOADER	A tractor or vehicle with a loading bucket on its front end. It is used to carry the compost material, and mix, construct, and teardown the compost and cure piles.
HEAVY METALS	Metallic elements with high molecular weights, such as cadmium, chromium, copper, zinc, etc. Some heavy metals may have health risks to humans, animals, and/or plants if present in excessive concentrations or amounts. Presence of heavy metals in compost are generally monitored to ensure that no health hazards occur.

LEACHATE	The liquid that flows from the base of a composting pile. The leachate is assumed to contain material either dissolved or suspended from the waste/composting material.
MESOPHILIC TEMPERATURES	Environment of moderate temperature between 40°F to 110°F (4°C S to 43°C). Mesophilic microorganisms are most common at the beginning and later stages of the compost process.
MULCH	Material put between rows or around the base of plants to reduce the loss of moisture from the soil and discourage the growth of weeds. Grass clippings, wood chips, sawdust, and straw are commonly used as mulches.
N:P:K RATIO	The ratio of nitrogen to phosphorus to potassium in a compost product. It indicates the fertilizer value of the compost.
ORGANIC WASTE	Waste composed of materials that contain carbon to carbon bonds and are biodegradable or compostable. Organic wastes include paper, wood, food wastes, yard wastes, and leaves.
OXYGEN DEMAND	The requirement for oxygen in aerobic decomposition by microbial respiration (activity).
PATHOGEN	Any organisms capable of producing disease or infection. Pathogens are often found in waste material. High temperatures (above 131°F or 55°C) over a period of three consecutive days has been shown to effectively kill pathogens.
PHYTOTOXICITY	Toxic response of plants to metabolites contained in unstable (immature) compost.
PUTRESCIBLE PROCESS	Decomposition or breakdown of organic materials with the emission (giving off) of foul (bad, putrid) odors.
RUN-OFF	Any liquid originating from any part of a compost facility that drains over the land surface.
SCREENING	The process of passing compost through a screen or sieve to remove large organic or inorganic materials and improve the consistency and quality of the end product.
SELF HEATING	Spontaneous increase in temperature of organic masses resulting from the composting or microbial action.

SHREDDER	A mechanical device used to break waste materials into smaller pieces, usually in the form of irregularly shaped strips. Shredding devices include tub grinders, hammer mills, shears, drum pulverizers, wet pulpers, and rasp mills.
SOIL AMENDMENT	A soil additive that stabilizes the soil, improves its resistance to erosion, increases its permeability to air and water, improves its texture and the resistance of its surface to crusting, makes it easier to cultivate, or otherwise improve its quality.
STABILIZATION	The decomposition or breakdown of compost to the point where it does not reheat when wetted or give off offensive odors.
THERMOPHILIC TEMPERATURES	Environment of higher temperatures ranging from 113°F - 155°F (45°C to 68°C). Thermophilic microorganisms thrive when the compost pile heats up.
VECTOR	Any organism capable of transmitting a pathogen to another organism, such as mosquitoes or rats.
WET TON	Two thousand pounds of material, "as is". It is the sum of the dry weight of the material plus its moisture content. Yard waste weighed on truck scales would typically be reported this way.
WINDROW COMPOSTING	A method of composting leaves in long piles. The piles or "windrows" are turned periodically to aerate and mix the leaves, thus speeding up the decomposition process and reducing odors.
YARD DEBRIS	Garden wastes, leaves, grass clippings, weeds, brush.

APPENDIX B -COST ESTIMATE FOR AERATED STATIC PILE COMPOSTING PILOT TEST



APPENDIX C - INTERIM GUIDELINES FOR COMPOST QUALITY

The Washington State Department of Ecology formally issued the Interim Guidelines for Compost Quality (Publication #94-38) in April 1994. The Guidelines were developed to recommend consistent statewide standards for compost quality and to provide guidance to county jurisdictional health departments or districts (JHDs), and producers of compost. The guidelines state, in part, the following:

> "The Guidelines are not a rule, but rather they serve as recommended standards for compost quality. Testing requirements and allowable contamination levels for physical, chemical and biological parameters are provided as suggestions to JHDs. The local JHD issues the permit under which a compost facility operates. Ecology reviews permit applications as submitted by the JHD. Individual JHDs may require more or less stringent standards, as appropriate, given the unique circumstances under which compost will be manufactured and used in their jurisdictions."

> "A state rule is currently being drafted that will apply to biosolids and will parallel EPA's 40 CFR Part 503 rule. Consequently, Ecology recommends that the Guidelines not apply to composted materials that contain a significant proportion of biosolids unless the non-biosolids feedstocks contain levels of pollutants which exceed levels in the biosolids and may pose a threat to human health and environment in the final compost product. However, Ecology recommends that composted material that contains insignificant proportions of biosolids be subject to these guidelines. JHDs are not bound to this recommendation. Significant proportions of biosolids in compost might be determined by examining the relative percentage dry weight, percentage nitrogen contribution, or other measures and through the use of professional judgment. The results of an informal survey of biosolids composting operations in Washington indicate that a range of 13 percent to more than 30 percent biosolids feedstock on a dry weight basis is used to make compost. Levels of biosolids feedstock below this range, for instance less than 10 percent, might be considered insignificant proportions."

> "The Guidelines identify Grade AA and Grade A compost that are available to the general public. Both are equally protective of the environment and public health when used in accordance with the Guidelines. Ecology recommends that Grade AA or Grade A compost be applied at a rate of up to 200 dry metric tonnes per hectare (90 dry tons per acre) annually for most purposes. Application rates will vary with the bulk density and percent moisture of each unique compost product. Ecology recommends three inches per year as a default."

WORKSHOP NOTES

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