Aerated static pile composting is the most common composting system for small municipal wastewater treatment facilities. However, because these systems require specially constructed flooring units, pipes, and energy to run the blowers, they are more expensive to operate than unaerated static pile systems. **Figure 7.5** is a photograph of a concrete pad with permanent vents for static aerated composting.

Figure 7.5: Aerated static pile compost flooring (R. Rynk et al., 2000).

7.5.2 Windrow

There are two main types of windrow composting systems: passively aerated windrows and turned windrows.

a. Passively Aerated Windrow

Similar to static piles, passively aerated windrows are formed with thoroughly mixed manure, amendments, and bulking agents. Passively aerated windrows differ in that air is supplied to the materials through open-ended perforated pipes buried beneath the windrows. No blowers are required. Generally, passively aerated windrows are 1.25 to 2.75 meters tall (4.1 to 9 feet) and three meters (9.8 feet) wide and can be any length (Bonhotal, 2001). **Figure 7.6** is a diagram of a passively aerated windrow.

The piles should be set on a porous foundation, such as gravel over sand, to absorb moisture and leachate, which can pose pollution risks for groundwater, and to provide insulation. Otherwise a system for collecting leachate should be put in place. Pipes or ditches may direct

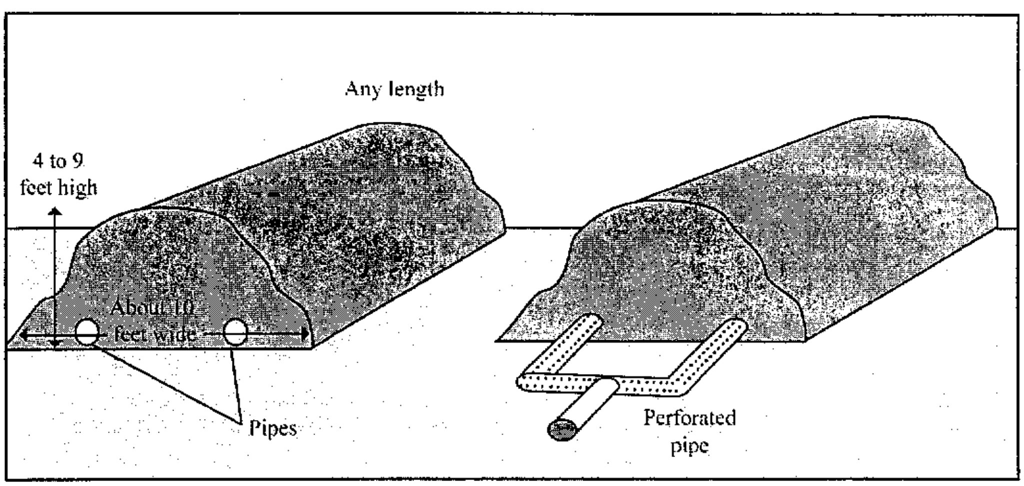

Figure 7.6: Diagram of passively aerated windrow process (United States Department of Agriculture, 1992).

leachate to grass filter strips or to another waste storage and treatment facility. A layer of bulking agent on top of the windrow can provide additional insulation; absorb moisture, ammonia, and odor; and repel vectors. **Figure 7.7** is a photograph of a passively aerated windrow.

Figure 7.7: Photograph of passively aerated windrow (R. Rynk et al., 2000).

b. Turned Windrow

Turned windrow composting systems are one of the most recognized and popular composting systems. In this system, the entire mass of compost is turned on a regular basis. Turning brings the organic matter on the exterior of the windrow into contact with the bacteria concentrated in the interior of the pile. Turning facilitates thorough decomposition and more homogenous compost. Turning or agitating has other benefits such as increasing the windrow's porosity, and releasing trapped heat, water vapor, and gases. Turning can be accomplished by hand, by non-specialized farm equipment like a front-end loader, or by specialized windrow-turning equipment. **Figures 7.8-7.10** illustrate several equipment options for turning windrows.

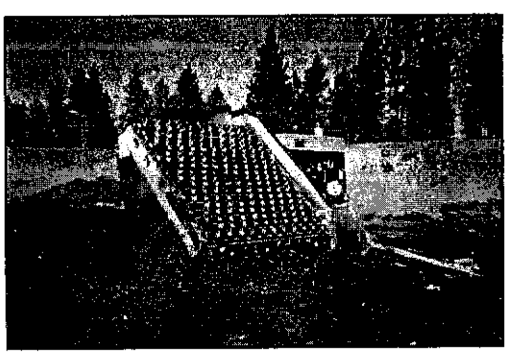

Figure 7.8: Inclined turner (R. Rynk et al., 2000).

Figure 7.9: Self-propelled turner (R. Rynk et al., 2000).

Figure 7.10: Front-end loader (Cayuga Nature Center, 2001).

Generally, windrows are turned every other day. The windrows are turned until the compost no longer reheats after turning. Failure to reheat indicates that bacterial activity has declined as a consequence of thorough decomposition. The EPA pathogen reduction requirements demand that windrows be turned five times in 15 days and that a temperature of 55° C (131° F) or greater be maintained for that period of time (Code of Federal Regulations, 2004).

The exact design of a turned windrow composting system depends on local conditions, labor availability, and cost. Generally, windrows tend to be 1.5 to two meters (4.9 to 6.6 feet) high and three to 3.75 meters (9.8 to 12.3 feet) wide and any length (Bonhotal, 2001).

Most states require a paved pad under windrows and a system to collect, control, and treat runoff and leachate from the composting area. Good drainage is essential for windrows located outdoors in areas with an extended wet season. Well drained areas also allow for the windrow to be turned during rainy and muddy conditions. Runoff from the area should be handled in the same manner as runoff from animal confinement areas. **Figure 7.11** is a photograph of a turned windrow system.

7.5.3 In-Vessel

In-vessel composting systems are mechanical systems. They are the most expensive composting systems, but require the least amount of land and time. The compostable material with the appropriate amendments and bulking agents is placed in an enclosed vessel. Forced air and mixing hastens composting. Since the compost is contained inside a vessel the compost is protected from climatic conditions. The compost must be cured outside of the vessel. **Figure 7.12** illustrates an in-vessel composter.

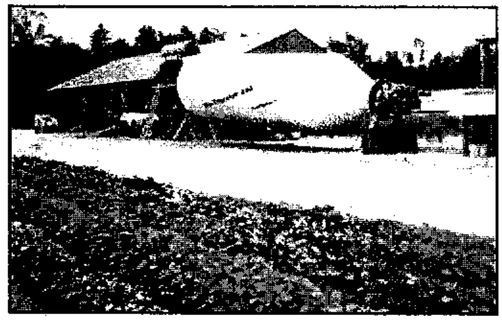

Figure 7.12: In-vessel composter (EnviroGro Solutions, Inc., 2003).

7.5.4 Other Composting Designs

Some composting designs do not fit into the traditional categorization scheme because of the setup of the composting process or the composting mechanism. Three such systems are pit composting, in-barn composting, and vermicomposting.

Figure 7.11: Turned windrows (J. Robbins, 2004).

a. Pit

Pit composting generally consists of rectangular cross-sectional pits. The compostable material mixed with appropriate amendments and bulking agents is placed in the pit and agitated. Mechanical stirring devices ride along dividing walls to mix the compost with paddles, or the compost can also be turned with a front-end loader. The front-end loader moves plugs of compost from one pit to another for aeration, temperature, and moisture control. The width of the system depends upon the kind of agitating method chosen. Pit composting systems may be of any length.

b. In-Barn

In-barn composting systems, sometimes called in-building systems, are used primarily for managing swine waste. In this simple system, up to three feet of bedding material, feces, and urine are left in the housing facility with the animals. When the animals walk and move around, their feet grind and incorporate the manure and bedding together. The compost is later removed for curing and replaced with new bedding.

Concerns with this system include preventing surface compaction, breaking up compaction if it does occur, and adjusting moisture content. Animal watering systems must be carefully controlled in order to prevent excessive moisture contents.

c. Vermicomposting

Vermicomposting utilizes worms to consume and degrade organic matter. Tunneling and burrowing worms aerate the manure. Despite the name, vermicomposting is not technically composting as the organic matter does not reach high temperatures. The worms' excrement, called castings, is a valuable fertilizer and soil amendment. For more information on this treatment technology, see Chapter 9, Miscellaneous Treatment Technologies.

7.6 Compost as a Value-Added Product

The major benefit of composting is that it turns a liability, manure, into an asset, a stable nutrient-rich product that can be marketed for retail and high-value uses. It is generally high in **macronutrients** required for plant growth—nitrogen (N), phosphorus (P), and potassium (K). The amount of nitrogen in the compost depends on the initial amount in the manure and the amount of ammonia volatilized during composting. Phosphorus and potassium losses to the environment are generally negligible unless leaching occurs during the composting process. Cured compost should be tested for its nutrient content. It can be supplemented with chemical fertilizers and other additives such as sand, top soil, and vermiculite to create balanced products for various uses. Compost provides slow-releasing nutrients for plant uptake. This, combined with reduced odor and pathogen concentrations, makes compost a preferred fertilizer over raw manure. If selling the compost is a goal, relationships with local landscaping businesses, nurseries, hardware stores, and other outlets is a vital part of a successful farm business plan. Compost sold to the public should be screened for debris, ground for a uniform consistency, and bagged after curing to prevent contamination before and after sale.

Macronutrient: An element required in relatively large amounts for growth and reproduction; nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S).

Fecal coliform: A group of bacteria in the family *Enterobacteriaceae* and commonly found in the digestive tracts of all mammals. The presence of fecal coliform in water may indicate fecal contamination and the existence of pathogens.

MPN: Most Probable Number, a unit used to quantify the results from certain microorganism counts.

7.6.1 Compost Class

Compost is characterized by its class. The US Environmental Protection Agency has developed a classification system for treated waste, including treated manure. This system rates the pathogen content of the compost or biosolids. This classification system is used to determine what compost is legally suitable to sell or give away to the public.

a. Class A Biosolids

Class A Biosolids must have a **fecal coliform** density of less than 1000 **MPN**/g on a total dry solids basis or have a *Salmonella* specific density of less than three MPN/4g on a total dry solids basis (Code of Federal Regulations, 2004a). Compost meeting the Class A Biosolids requirements may be used by the general public, by nurseries, gardens, and golf courses. Class A is required for biosolids to be sold or given away in a container, or to be applied to home gardens and lawns.

b. Class B Biosolids

Class B Biosolids meet the minimum level of pathogen reduction for land application and surface disposal, unless they are placed in a surface disposal facility covered daily, such as landfills. To meet Class B Biosolids requirements, the biosolids must be treated with a process that reduces but does not necessarily eliminate pathogens. Class B Biosolids have a fecal coliform limit of less than 2×10^6 MPN/g on a total solids basis (Code of Federal Regulations, 2004a). Permitting and site management are required for the use of Class B Biosolids.

7.6.2 Compost Quality

While compost class is concerned with the safety of the compost, the quality rankings are based more on appearance, scent, and price of the compost.

a. Boutique

The highest quality compost is known as boutique compost. It is the most expensive compost to purchase and has a very uniform and rich texture. Boutique compost is not heated any longer than other compost but it may be cured longer and is carefully screened and ground for uniformity. While all compost has a generally agreeable scent, boutique compost tends to have very little or no detectable odor. Boutique compost is usually sold in small quantities and often is used inside for house plants or window gardens.

b. Bagged

The next lower quality compost is bagged compost. Bagged compost is less uniform than boutique compost and may have an earthier scent. This compost may be sold in various bag sizes and is often purchased by the general public for outdoor gardening and landscaping. **Figure 7.13** is a photograph of bagged compost and a bagging machine.

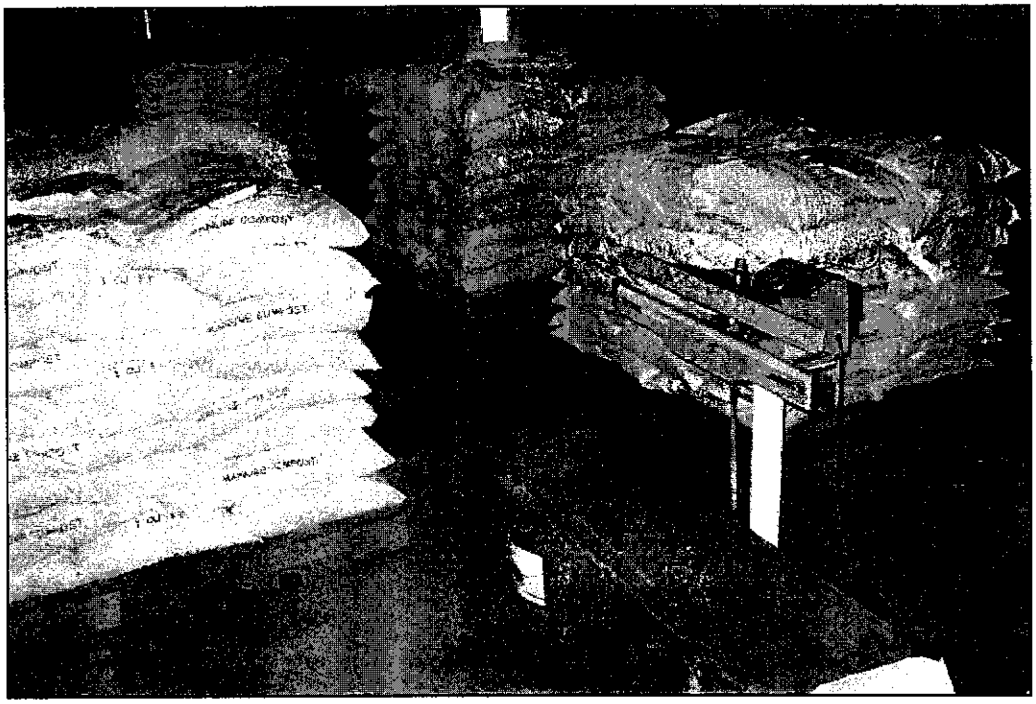

Figure 7.13: Bagged compost (J. Robbins, 2004).

c. Bulk

Bulk compost is the lowest quality and cheapest of the three composts to purchase. It is sold in large quantities (by the ton or truckload), and may have the strongest scent. Bulk compost is generally not screened as well as boutique or bagged compost and is not as uniform. Bulk compost is usually purchased by farms, nurseries, or professional landscapers.

7.7 Summary

Composting capitalizes on the natural process of decomposition that occurs in temperature ranges between 0 and 70°C (32 and 158°F) when there is an adequate supply of water, oxygen, and biodegradable organic matter. Composting is an aerobic decomposition process that stabilizes manure organic matter and reduces manure odors and pathogens. Bulking agents or amendments may be added to the compostable material in order to achieve the appropriate carbon-to-nitrogen ratio, moisture content, and bulk density. Aeration and temperature are key to designing a successful composting system. Static, windrow, and in-vessel are the three main kinds of composting systems. Compost may be considered a Class A or Class B Biosolid, depending on the pathogen count. Class A Biosolid compost may be sold as boutique, bagged, or bulk compost.

7.8 A Closer Look At Composting

The Fessenden Dairy, a family farm established in 1863, is nestled in the Finger Lakes region of New York State. The dairy has experienced constant growth since 1919 when milk was first sent to New York City by train. The farm now milks about 550 cows and cares for about 500 heifers and calves. In addition to the cows, the farm includes about 1000 acres of silage corn and alfalfa and grass for forage. Tim Fessenden has been working the family farm since 1976.

What sets the Fessenden Dairy apart from the herd is their close association with the community. Tim is committed to forging and maintaining good relationships with his neighbors, addressing complaints quickly, and farming in an environmentally and financially sustainable manner. In order to do that, Tim explored using alternative treatments as part of a broader manure management plan.

Figure 7.14: Compost and bags (J. Robbins, 2004).

In 1999, with the help of the Syracuse University Environmental School of Forestry, Tim began implementing alternative manure management and treatment strategies. The Fessenden Dairy currently uses solids separation, aerated static pile composting, and vermicomposting. After the solids are separated, they are composted indoors at 150 °F for three weeks. The compost is then moved outdoors and formed into windrows on impermeable pads that are turned once a week for three to four months. At this point the compost is cured and ready for screening and grinding. A small portion is transferred to the vermicomposting unit for further treatment and to make boutique compost. Since 1999, the Fessenden Dairy has upgraded the pilot scale treatment processes to farm scale and sells their compost nationwide. The compost and vermicompost are marketed as Tender Loving Compost™, and are pictured in **figures 7.14** and **7.15.**

Tim also experimented with aerobic digestion and greenhouse biofiltration. While these technologies weren't successful right away, Tim is working on new designs and intends to put them back into the system as well as adding a nitrification-denitrification process.

Tim likes the low-tech systems approach that the dairy uses, but the manure treatment is more intense, requiring a different level of management. The time commitment is greater and so is the need for skilled workers. He estimates that about 30 to 40 percent of the day is spent on manure management and monitoring the treatment system, versus only two percent prior to 1995, and that ten to 15 percent of the farm's total work labor is devoted to manure management, including the marketing of the compost.

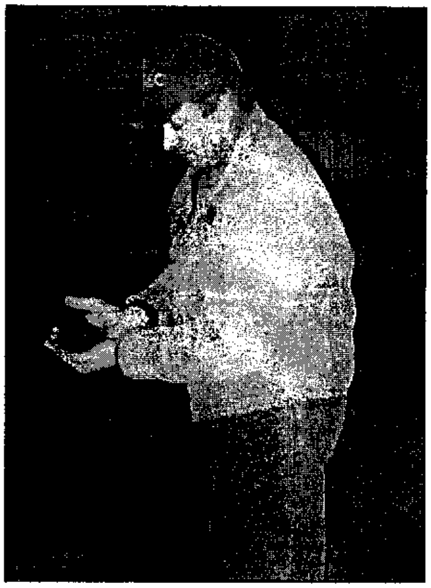

Figure 7.15: Tim Fessenden (J. Robbins, 2004).

Tim's advice to others contemplating alternative technologies is to surround yourself with an experienced and strong advisory group, to beware of advisors that only look at the financial aspects, to leave your options open, and to adopt a systems approach—never put all your eggs into one basket. While he is still waiting to see if his treatment technologies are economically viable in the long-term, Tim knows he is on the right track as others are trying similar treatment processes and trying to duplicate his successes.

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