Planning, design and operational factors all contribute to managing composting’s aromatic byproduct.

Odors are often the greatest source of public complaints with which a composting facility must contend. As residential and commercial developments begin to encroach on once remotely located facilities, off-site odor impacts become an issue of concern. To further exacerbate the situation, the encroachment is often a result of increased populations; more people produce more waste, and facilities must therefore deal with expansion pressures while working to improve odor control.

Odor sources
Many potential odor sources exist at a composting facility. The most obvious include the delivery and mixing of raw feedstock materials, active composting and curing (see Figure 1). Other potential sources including the movement of compost and raw materials around the site, leachate puddles, screening and storage of final product. In addition to general housekeeping issues such as maintaining a clean site, optimization of the composting process can help to minimize odor generation. Key issues to consider are feedstock handling, mix ratios, aeration rates and temperature control.

Feedstock handling.
Different feedstocks have different odor potential. For example, grass typically is a significant source of odor at yard debris facilities. Fish wastes and certain vegetable wastes are more odorous than food processing wastes. Facilities should be prepared to handle incoming waste appropriately and to mix putrescible materials with bulking agents (such as woodchips or leaves) immediately after they arrive.

Mix ratios. The ratio of materials combined to form the compost feedstock is significant because it determines moisture content, pore space and the carbon-to-nitrogen (C:N) ratio of the mix. For most composting systems, the initial solids content of the compost mix should be at least 40 percent (i.e., less than 60 percent moisture). Excess moisture reduces pore space and impedes the even flow of air through the composting material, resulting in anaerobic pockets. Insufficient moisture inhibits the microbial composting activity, slowing degradation. The C:N ratio of a composting mix should be between 25:1 and 30:1. A lower ratio (excess nitrogen) results in the loss of ammonia, which may lead to odor problems. A mix with a higher C:N ratio may have insufficient nitrogen for optimum microbial degradation of carbon, and composting will be slowed.

Aeration rates. Aeration is one of the most important elements of a composting system because oxygen is essential to microbial activity. Although both aerobic and anaerobic degradation can result in odors, more odorous compounds are generated under anaerobic conditions than aerobic conditions. Compost piles are aerated by agitation, in the case of windrow systems; forced aeration operated by mechanical blowers, in the case of aerated static piles; and by both forced aeration and agitation in many in-vessel systems. The aeration system must be sized carefully in order to provide enough air to composting microbes without excessively removing heat and moisture from the pile. Moisture content and pore size are important elements to a proper aeration system; excess moisture or overly dense material will impede aeration and increases the potential for odor generation.

Temperature control. Temperature con-

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biodegradable plastic bags. However, Lawrence Winter, the city's program manager, notes, "They are very expensive."

**Swap them out/don't swap them out.** Many programs provide carts to participants, which then are emptied on a scheduled basis. In other programs, the collector brings clean, empty carts to be swapped for full carts. Although the latter approach requires investment in extra carts, several advantages are evident. The carts can be cleaned out at the compost site, thus mitigating odor issues for program participants. In addition, swapping carts may require a less expensive collection vehicle, such as a stakeside flatbed truck with a lift gate, rather than a garbage collection truck with cart tipper.

**Aerate them/don't aerate them.** A number of collection programs have chosen to provide some form of aeration for the carts used to store food discards. For example, the typical residential scrap food cart used in Nova Scotia is aerated, although program officials encourage residents to wrap meat scraps in old newspapers before placing the material in the cart, especially in the summer. In most of these programs, the carts are emptied every other week (garbage is picked up the alternate week and recyclables are collected weekly).

The Chittenden program used aerated carts as part of a residential collection program last summer. In this effort, residents could put out all types of scrap food, including vegetative matter, meat, fish, poultry, soiled paper, laminated paper and laundry lint. According to Nancy Plunkett of the district’s recycling staff, a few residents experienced problems in terms of odor, flies or maggots.

**Collect it separately**

As a rule, food scraps are collected separately in an assigned truck, such as a standard rear-loading waste collection vehicle with a cart tipper.

Some programs utilize specially designed vehicles. Wood Recycle and Compost Center modified a rolloff truck to install a specially designed lift and nonleaking compost container.

**Collect it with garbage**

Other communities are trying to avoid the cost of sending a truck out solely to pick up food discards.

In Hutchinson, for instance, a new citywide waste collection system will be implemented this summer when the city opens its new in-vessel composting facility. At that time, the program will change to entail simultaneous pickup of garbage and organics in a divided-body truck (recyclables will continue to be collected separately in another truck).

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**What is best**

Evidence to date suggests no one method of scrap food storage and transport is preferred. To generate sufficient information for designing a sizable scrap food recovery system for San Francisco, some 500 businesses were provided service (see “Curbside Recycling: The Next Generation” in last month’s issue of Resource Recycling). A variety of approaches were tested including a mixture of cart sizes (primarily 32- and 64-gallon units) and front-loader bins (primarily one- and two-cubic-yard units).

According to Steve Sherman of Applied Compost Consulting (Oakland), a consultant involved with the San Francisco effort, “The experience shows that all configurations work.” Sherman and other experts note that the precise design of a local system has to take into consideration site-specific considerations, such as space for food discards storage before collection and access to those containers by collectors.

The experts also suggest that as food scrap recovery becomes more common, new storage and transport equipment will be developed for this surging market.

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control of composting piles through the adjustment of aeration rates is also an important operational parameter. Conflicting data exist regarding the effect of high temperatures on odor generation. Higher temperatures typically result in increased odor generation. Odor character and strength of compounds formed at higher temperatures are quite discernable, even at large distances. However, if material comports at higher temperatures, less air is used to cool the pile and, therefore, the volume of emissions is lower. Total odor generation is a function of both odor concentration and the volume of emissions from a pile; the overall effect of higher pile temperatures is not clear. However, it is certain that maintaining uniform temperatures throughout piles and optimizing the rate of composting will help to minimize odor generation.

Odor mitigation
Site odor can be mitigated by several means. These include counteractants and masking agents that are sprayed over a site or specific odor sources; chemical scrubbers that adsorb or oxidize odorous gases by passing them through scrubbing processes; and biofilters that utilize natural microbial activity to break down odorous compounds.

Counteractants and masking agents.
Both counteractants and masking agents typically are applied through a fine-mist spray system. The mist can be sprayed directly over odor sources, or mist may be sprayed from points around the perimeter to prevent odor from moving off-site.

Masking agents are designed to cover up odors, while counteractants are meant to react with odorous compounds and alter their character and intensity. In both cases, the effectiveness depends in large part on ensuring contact between odorous compounds and the spray particles. In general, they have not been very successful at composting facilities.

Chemical scrubbers.
Chemical scrubber systems pass scrubbing solutions through the emissions air stream to remove odorous gases by adsorption or oxidation. Scrubbers typically are best suited to low-volume, high-concentration odorous exhaust air, so they are not always appropriate for composting facilities that generate a large volume of exhaust. In addition, since compost exhaust typically contains multiple odor-causing compounds, multi-stage scrubber systems often are required for effective odor control. Using scrubbers requires chemical handling and storage, and scrubber maintenance can be expensive due to the cost of chemical agents.

Biofilters.
Biofilters use the naturally occurring microbial populations within a solid media matrix to adsorb and biologically degrade odorous air pollutants. Biofilter media typically consists of compost, bark, woodchips, soil, sand or a mixture of these and other materials. Biofilter design often includes a humidification system that moistens exhaust air as it moves from the composting process to the biofilter plenum. The stone plenum and a system of aeration piping distribute the exhaust air evenly throughout the biofilter media, which removes a wide range of odorous compounds. The advantage of biofiltration is that the biological system can remove multiple compounds at low operating cost. The primary disadvantage of biofilters is they require a relatively large area.

Odor modeling
The success of any odor control system depends on the ability of the system to capture a high percentage of odorous emissions generated and the effectiveness of odor treatment. However, the potential for off-site odor impacts also depends on the dispersion patterns from an odor source. Dispersion is dependent on source parameters such as height and velocity, local topography and meteorology. Odor models can be used to determine the direction of dispersion and the
potential for off-site odor impacts. Air dispersion modeling can be used to evaluate the movement of odor from a source and determine the extent and frequency of odor impacts on a surrounding community. Models often are used as part of the permitting process to determine if a proposed facility will create odor nuisance conditions. Models also are used by existing facilities to evaluate proposed expansions or operational modifications. For example, a model can be used to compare different odor control scenarios.
so that the most cost-effective solution can be identified.

The model that typically is used for composting facilities is the ISCST3 model, recommended by the U.S. Environmental Protection Agency (Washington). This model takes local topographical and meteorological data into account, and combines this information with emissions concentrations, site layout, operational parameters and source dimensions to determine the movement of odors from the source. The results are expressed as a series of isopleths — concentric circles that are drawn based on the maximum odor concentration projected to occur at points surrounding the facility. An example of modeling results is shown in Figure 2.

The source of odors is a green biofilter in the southwest corner of a facility. Odor dispersion isopleths show that off-site odor concentrations will range from three to five D/T (dilution to threshold) units in the residential development to the west. Points along the border of the site are projected to experience concentrations in the range of five to 13 D/T.

The concentration at which a particular odor creates nuisance conditions depends on the intensity of that specific odor. Odor analysis data from various composting operations have shown that compost odors typically constitute a nuisance condition at five to seven D/T. Based on this nuisance threshold, all points on the left graph within Figure 2 that fall within the five-D/T isopleth are projected to experience at least one 10-minute odor nuisance condition per year under the meteorological conditions modeled (typically one to five years of meteorological data are used). The results of this model were unacceptable to the residents of the community, since many of their homes, the school and the local state park were projected to experience odors.

The model then was run incorporating an enclosed biofilter with two roof vents. Although in this scenario, the same number of odor D/T still was emitted from the biofilter surface, enclosing the biofilter improved odor dispersion by several means. First, since an enclosed biofilter must be sufficiently tall to allow a front-end loader access to the media, roof vents were at a much higher height than the open biofilter. The vents also released air at a higher velocity than the open biofilter. Both added velocity and height increase the rate at which exhaust air mixes with ambient air, increasing dispersion. In addition, make-up air added to the biofilter exhaust to boost biofilter emissions through the vents diluted the emissions before they were released.

The resulting model output is shown on the center graph within Figure 2. Enclosing the biofilter greatly reduced the range of odor impacts, but some off-site impacts still were projected. The biofilter scenario, therefore, was run a third time.

For the third scenario, an additional 10 percent make-up air was added to the exhaust, and the number of roof vents was increased to four. As shown on the right-hand graph within Figure 2, the result for this scenario was a complete elimination of off-site odor impacts.

The model can be used to project the number of odor impacts at a particular receptor point and to determine the conditions under which impacts are likely to take place. A facility then can use this information to select the best odor control option. For example, if odor impacts were found to occur off-site only during late night hours, or only during winter weather conditions, a community might be satisfied with this odor control option. Other communities might have a zero-tolerance policy and would not accept any odor impacts, regardless of the cost of mitigation. The model allows a facility to examine options and their effectiveness before investing in site equipment or construction.