THE siting of a compost facility can be an expensive and time-consuming activity that causes ill will between the proposed developer (either a public agency or a private entity) and site neighbors. Historically, the issues of concern have included truck traffic, noise and odors. The truck traffic issue usually has been addressed by counting current vehicular use and estimating additional traffic expected at the facility. With this information, the developer can project impacts on local roads and propose mitigating measures, such as use of alternate routes, widening of roads, addition of stop signs and traffic signals, and, if necessary, limitations on delivery schedules. Likewise, it often has been possible to address the noise issue by citing National Institute of Occupational Safety and Health, U.S. Environmental Protection Agency, and Occupational Safety and Health Administration standards for equipment, proposing enclosures or noise barriers, or limiting hours of operation.

Dealing with the issues and concerns about odor is a much more contentious and difficult task due to the pervasive nature of the emissions, the lack of defined standards, the subjective nature of what is objectionable, and the public concern about health impacts related to odor. The difficulty of defining the concerns in terms the public can understand is further compounded by the history of odorous compost facilities elsewhere, general public concerns with any waste management facility, and last, but certainly not least, representations made by developers that their facility will be “odor-free” or will “produce no odors” with no back-up to substantiate such claims. To address this situation, an odor predictive model can be used both to determine the impact of a composting facility on a neighborhood and the adequacy of the facility design in terms of odor control.

Odor Generation And Off-Site Impacts
Odor can be generated by composting activities, including materials receiving, mixing, pile building, active composting, pile turning and breakdown, screening, curing, storage and drying. Some miscellaneous sources include emissions from odor control systems (e.g. biofilters or scrubbers), runoff, site ponding and front-end loaders (diesel fumes). Not all of these sources are constant, nor are they all equally strong or potentially objectionable. For example, most facilities which compost biosolids mix them with a bulking agent source quite soon after delivery. For this reason, even though the biosolids are generally considered to have an objectionable odor, they are a source of odor emissions for a relatively short period of time each day. Alternately, wood chips, generally considered to have a pleasant odor, are frequently stored outdoors in large amounts and are, therefore, a constant source of odor (even if generally not objectionable).

Another constant source of odor is the air stream emitted from an odor control device. This odor can have distinctive characteristics that make it easily identifiable. Not all odor sources listed above are present at every compost site. Each source has unique qualities in terms of odor strength and characteristics. These individual odors also can combine to create new and additional odors. Thus, no matter what degree of odor containment and treatment, method of composting or feedstocks to be composted, there will be some odor generated at the compost site.

If one takes the generation of odors as a given, the next issue to be resolved is, will this odor migrate off-site to impact neighbors? Further, will these neighbors consider the odor to be a nuisance? The first question is easier to answer than the second. Because of the lack of agreement on what a nuisance odor is, it is imperative that the level of odor...
be reduced to as close to ambient as possible. Given this goal, it is beneficial to determine how odors, once generated, can move off-site.

As an initial illustration, consider a room with no air handling equipment, and place a constant, but small, odor source in the room. This could be perfume released from a wick. Initially, the odor would not be noticeable, except near the perfume wick. However, as time passes, the influence of the odor would continue to build, and eventually, the room would be filled with the odor. If the walls were removed or a door opened, the odor would move out of the room. This first example illustrates what happens during an inversion — when the air, in essence, becomes “saturated” with odor. The amount of odor units required for the saturation is a function of the strength of the odor emitter, so the time required to saturate the air with odor will vary.

As a second illustration, consider the same room with the same perfume released from a wick, but now there is a very slow fan wafting the odorous air to the north side of the room. In this case, somebody standing at a door on the north side of the room would smell the perfume before the air was saturated, but somebody standing at a door on the south side would never smell the perfume.

In both illustrations, the same number of odor units are released. However, in the first, the entire room's air is saturated with odor, and in the second, the room's air will never be saturated, and the odor only will be noticed downwind of the fan. The second example demonstrates what happens under weather conditions of a slight but consistent wind.

A third illustration is one where the same room has a high-efficiency ventilation system in place, bringing clean air into the room at a rate sufficient to dilute the effect of the perfume so that it is below detectable concentration when it reaches the edge of the room. In this case, no person outside of the room would ever smell the perfume, no matter where they stood. This illustration is similar to what happens during turbulent weather conditions.

These three illustrations depict some of the extreme meteorological conditions that can occur at a compost site and show why even small compost facilities located a long distance from neighbors can, under the first illustration, cause odor impacts, while under the third illustration, a large compost facility right next to a residential neighborhood might not generate odor complaints during turbulent weather conditions.

Tried And Not So True Strategies

Odor control strategies that have been used to site and/or expand compost facilities in the past have not always been successful. They were more subjective, such as the following:

“I compost five tons/day. There will be no problem enlarging to 25 tons/day on this site.”

“We maintain the oxygen content of the piles over 10 percent, so there should be no off-site odor impacts.”

“We successfully operate a 50 ton/day facility at Location A, so there will be no problem building an identical facility at Location B.”

“Our nearest neighbor is over a quarter-mile away, so we anticipate no problems.”

“Our neighbors are all commercial and industrial properties, so there should not be any odor complaints.”

“We only compost yard waste, so there should not be any problems.”

These strategies are typically unsuccessful because they are not based on a rigorous technical analysis, which takes into consideration atmospheric conditions, as described in the previous section, as well as topographical impacts and other factors. To predict how “real world” situations can affect potential site odor impacts, it is necessary to utilize modeling techniques.

Air Modeling

Atmospheric dispersion modeling is a technique for estimating odor concentrations that are caused by emissions from a source. While it is not possible to fully model the complexities of the atmosphere and the exact transport and dispersion of an odor, a series of mathematical formulae have been developed from empirical and theoretical studies to reliably estimate odor concentrations. Incorporating these formulae into computer-based models greatly increases the ability to model numerous sources and receptors as well as quickly and efficiently compare various odor control strategies and their impact on odor concentration at receptor locations. In particular, dispersion models allow one to readily evaluate the changes in receptor concentrations due to changes in the size of facility operations, the size of odor sources, and odor concentrations.

Odor concentrations can be measured in “dilutions to threshold” (D/T) — the number of volumes of clean (odor-free) air that would be necessary to dilute one volume of site air to the level at which the average person could not identify the odor. Odor intensity varies depending on the mix of compounds which make up the odor. Odor panel analysis rates odor in terms of concentration and dose response (i.e., intensity). The butanol equivalent scale, along with this information, can
be used to calculate intensity. This data then can be used to calculate the level at which a particular odor is likely to result in an odor nuisance.

A variety of air dispersion models are available for assessing the impact of composting-related odors. The one employed most often is the EPA ISTSC3 industrial source short-term model. It can be used for specific compounds as well as odors to determine compliance with air quality regulations.

Several types of inputs are factored in to determine dispersion. These include local topography, meteorological data, output concentration, output dimensions, facility layout, and hours of operation. This information is put into the model, the model is run, and the dispersion pattern of odor or specific compounds is expressed as a series of isopleths or concentric rings around the source. The figures used in this article show typical modeling results. As shown, the isopleths are marked with the peak 10-minute odor concentration projected to occur over the period of time modeled.

The isopleths can be used to identify the areas in which odor impacts are projected to occur. For example, in the case of composting, five dilutions to threshold (D/T) is often used as an odor threshold — the point at which the community is likely to detect the odor and consider it a nuisance. This is based on much of the odor data that has been collected at composting facilities. This threshold will vary depending on the type of odors, so for other kinds of facilities, it may be higher or lower. Some states have used seven D/T as a threshold, and others have required the use of five D/T or two D/T. If five D/T is considered your odor threshold, then the area within the line labeled five D/T is projected to experience at least one odor impact over a one-year period under the meteorological conditions that occurred during the year modeled.

The model also can be used to determine the number of impacts projected to occur within the one-year modeling period as well as the meteorological conditions under which they are likely to occur. This can help facilities determine the extent of odor control necessary. Some communities, for example, may tolerate a few odor impacts each year, while others may have a zero tolerance policy.

Although the model cannot pinpoint an exact time or date of impacts, the results can indicate the general conditions likely to correlate with odors. The time of day or season when impacts occur may also affect a community’s tolerance. For example, if the model determines that all of the projected impacts will take place between 2 a.m. and 4 a.m., or if all of the impacts will take place during winter months, it may change how a facility chooses to deal with odor control.

**Case Study**

The following case study illustrates use of the model. It involves a composting facility operating at a wastewater treatment plant. There already have been some odor complaints from the community, and the facility is planning to expand. The concern is that odors from the expanded facility will have a more widespread impact and that neighboring resort areas and planned developments to the south of the facility may be affected. Extrapolating from odor information collected at the existing facility, the expanded facility was modeled. It showed the projected impacts will affect a large area, including the major highway, the recreational trail, and the proposed development areas.

The model was run with specific receptor points to determine the number of impacts that particular areas might experience throughout the year. The results indicate that there will be a significant number of impacts at some of these points.

This facility is a good example of why odor modeling should be conducted before facilities are built. The particular topographical features of this region result in a movement of odors to the northwest of the facility. If modeling had been conducted before the facility was built, facility design or siting could have taken this into account, and odor impacts could have been avoided.

The next step was to identify some mitigation measures that might be taken to reduce odor generation on-site. Based on an odor balance, which compared the number of odor units generated from different sources, it was determined that components of the wastewater treatment plant and the mixing operation were the two most significant sources of odor. Models were run to examine the effect of enclosing either of these odor sources and treating emissions through a biofilter. Both models showed significant odor reduction, but the improvements were insufficient as high numbers of impacts were still projected. A third scenario, in which both the wastewater treatment sources and the mixing operation were enclosed and treated through a biofilter, was also included. This scenario also resulted in significant but insufficient odor reduction.

It should be noted that for the purpose of these three models, it was assumed that the biofilter treating these two exhaust sources would be similar to the biofilter currently on-site. Measurements taken at that biofilter had an odor concen-
tration of 71 D/T. This is higher than typical biofilter exhaust, so it was a conservative assumption that a new biofilter also would have this output.

Table 1 shows a summary of the number of odor impacts at each of the receptor points under these different scenarios. As shown in this table, the areas to the west, south and east, as represented by receptors 11, 13 and 15, respectively, were still projected to experience a large number of odor impacts.

Two additional options then were considered. The first was to improve the performance of the biofilter by changing the media. By reducing biofilter exhaust to 35 D/T — a performance level easily achieved by biofilters — impacts on the neighboring community were further reduced. The other option was to cover the biofilter and release biofilter exhaust through roof vents at a height of 12 feet. This reduced the projected odor impacts even further. There were still some impacts projected, as shown in Table 2, but the number was much reduced.

Examination of the model output files showed that about half of the impacts projected would occur between the hours of 11 p.m. and 6 a.m., when few people are outside. The majority of impacts were shown at Point 11, to the west of the facility, away from the anticipated development areas, so both of these scenarios would be much more acceptable to the community.

The next step for this facility, if it wanted to reduce odor impacts further, would be to look at the combination of improved biofilter efficiency and covering the biofilter, or perhaps consider installing large enough roof fans so that some of the makeup air mixed with building air would dilute the biofilter exhaust before it is released through the roof vents.

### Modeling Costs, Value

Considering the high cost of constructing odor control or altering a facility, or the difficulty of dealing with an irate public after a facility has had odor problems, modeling is a relatively inexpensive way to evaluate potential sites or facility design. A typical odor modeling project costs between $4,000 to $8,000 but may save a facility many times that amount in equipment costs or time spent on odor issues. Additional costs to sample odor sources and conduct odor analyses would be approximately $2,000 to $4,000.

More air quality regulators are requiring modeling work as part of permit applications. Models also provide a very visual presentation of the odor issue and can be used to demonstrate to the public that you are addressing their concerns about odor.

**Joel Alpert is with Compost and Technology Solutions, Inc. in Sharon, Massachusetts. Nerissa Wu was with E&A Environmental Consultants, Inc. in Canton, Massachusetts at the time this was written.**