Air Separation Strategies Tackle Plastics Contamination

Air separation equipment is just beginning to find use in compost production, with operators installing equipment to remove plastic from overs resulting from end product screening.

Robert Rynk

One of the biggest challenges in composting municipal solid waste, yard trimmings and food residuals is dealing with plastic. To keep feedstocks and/or compost free of plastics, operators have resorted to several methods — source separation, hand sorting, screening, and air separation (see "Sorting Out the Plastic," August 2000). Of these methods, air separation is probably the least familiar to composting facility operators. Although it routinely is used in recycling and other industries, air separation is just beginning to find use in compost production. A few innovative operators have adapted air separation machinery to serve their compost production systems. However, most are still waiting for equipment designed with compost in mind. Such equipment has now emerged on the scene and is beginning to find its niche.

Air Separation — How It Works

Air separation employs a stream of air to separate materials according to their density (although shape is also a factor — see sidebar). The concept is well illustrated by a conventional air separation system, commonly called air classification (Figure 1). The mixed materials are fed into a chute with an upward-flowing stream of air generated by a blower. The light materials are carried with the air. The heavy materials fall down into a bin or onto a conveyor. As the air stream continues with the light particles entrained, it enters a cyclone separator where the air velocity slows, causing the particles to settle out.

There are several variations of the concept. For example, a cyclone is not necessary to collect the light particles. It is just particularly good at this, especially for small particles like powders and dust. Other devices that slow the air velocity and thus capture the light particles also are used. Composters have used roll-off containers for this purpose.

In addition, the direction and mode of airflow can vary. The air can move as a result of a vacuum, with a fan above the feed, or by pressure, with the fan below the feed, or both. The air stream can be horizontal with the heavy particles carried along a conveyor or screen (Figure 2). Additional equipment may be in-
plementation. Each project adds an important piece to the odor generation and management puzzle, and maximizes the research dollars being invested.

The overall goals of the group are to: Gain a better understanding of the compounds responsible for odors in biosolids; Understand the conditions at the plant that promote production of these compounds; Evaluate the mechanisms responsible for generating these compounds; and Determine the critical control points in the treatment process and the process parameters that can be monitored to help predict and prevent nuisance odors. It was decided that in order to compare sampling data collected from the various research experiments, that every one should be using the same types of methodology. Methodologies like those being developed by Penn State are being utilized by the research group.

One of the concerns about involving EPA and state regulatory personnel in the group was the perception that the goal was to work toward regulatory limits for odor emissions. "The science really isn't there to regulate odors," notes Peot. "But in the process of getting various states involved with sampling at WWTPs, biosolids coordinators and regulators are seeing what is going on at plants and learning along with everyone else. They are seeing that the outcome of this process shouldn't be a regulation."

The group also has managed to sidestep the competitiveness and intellectual property issues often associated with research. "What we have are universities, companies and government agencies involved and what it all came down to is there is a lot of work to be done," adds Giani. "To get a complete study done, the reality is that we should be working together, which has helped in getting around the standard competitiveness of research." Adds Peot: "Naturally, people like to protect interests and intellectual property, but everyone has been very open."

The odor research group will consider other research proposals from WWTPs or a group of WWTPs if the financing is available to support the work. "The more facilities that come on board, the more situations we can look at and learn from," says Giani. "In turn, facilities can take advantage of various expertise and benefit from the focus of the whole group."

Most projects' results will be published individually over the next two years. At the end of 2002, the group hopes to provide a compilation of all the research conducted into a manual that can be used as a management tool for facility managers, design engineers and government agencies to control and optimize odors emitted from biosolids products.

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(TMA), ammonia and total reduced sulfurs (TRS). "If we could get a fast, accurate reading of those three, we would have a good fingerprint," he notes. "That is the direction we are heading, and we will need analytical equipment that can give us a fairly quick reading on a sample taken." In DCWASA's most recent contract with the three land application companies it uses, language was added that says if DCWASA directs the contractor to take the biosolids to the landfill, they must take it there and DCWASA will pay the difference between what it costs to land apply versus landfill.

He credits DCWASA's involvement with the National Biosolids Partnership's (NBP) Environmental Management System initiative as being the spark to the functional research approach being used and how to apply what is learned directly into improving the land application program. Blue Plains is one of 27 wastewater treatment agencies developing an EMS as part of the NBP's demonstration program. One of the first steps is to do a "gap analysis" of current management methods and biosolids practices to identify gaps or vulnerabilities in the system. "In the gap analysis, one of the first things we had to do was look at critical control points in the wastewater treatment system and biosolids management program that could affect biosolids in a negative way," says Peot. "Much of what we found in the analysis pointed to areas and control points that contribute to, or impact, odor generation. The EMS development process has provided an excellent framework to conduct the functional odor research because we can see the beneficial effects at the critical control points."

Some of the research results at Blue Plains include: The optimum lime dose required to reduce odors is affected by blending and proper incorporation of lime into the biosolids. Attaining a pH of 12 using currently recommended methods is a poor indicator of optimum lime dose; Addition of lime to sludge appears to be a catalyst for TMA production, as none was detected prior to lime addition; Higher lime doses do not increase the odors generated meaning that the amount of lime added (>15%) is not a limiting criteria for TMA production; Mercaptan concentration is typically very low in lime-stabilized biosolids that are properly mixed and stabilized; Polymer dosing research found that cationic polymers used for conditioning in centrifuges break down and produce aminated odors after liming; Dimethyl disulfide (DMDS) is the main reduced sulfur constituent in Blue Plains lime-stabilized biosolids (contributing as much as 70 percent of TRS compounds); and If the sludge is odorous prior to stabilization (such as from back-ups during processing), it will remain odorous after stabilization and the biosolids will contain odorous reduced sulfur compounds or volatile fatty acids generated in upstream processes.

Expanding on several of the findings listed above, Peot notes that dosing with lime to 15 percent on a dry weight basis to meet pH would meet regulatory standards but still can create odorous product, depending upon the quality of the mix. "We did experiments and cycled at different amounts, and now we have a policy to lime to 25 percent on a dry weight basis. We find that controls odors a lot better." In addition, research showed that when digested biosolids were blended with lime, TMA were released; conversely, when lime is added to undigested biosolids, TMA generation is much less. "As a result, we stopped doing lime doses with digested biosolids," says Peot. "In fact, we have quit running the digesters all together. New digesters are being built.
In composting situations, air separation is used toward the end of the process, removing plastic after grinding, composting, and screening. It is usually one of several steps that remove plastics from compost. Hand sorting and screening remain important components in producing a nearly plastics-free compost. In fact, it is the screening step that separates the plastic from the finished compost. Unfortunately, air separation cannot feasibly segregate plastics from finished compost products, at least with the techniques presently available. The density and aerodynamic qualities of plastic particles and compost are too similar for practical separation (see sidebar). Therefore, air separation is applied to the screen overs—the large fraction particles collected by the screen. The overs are primarily comprised of pieces of wood, which have substantially different densities than the plastics, at least the film plastics.

There are advantages to taking the plastic out of screen overs. First, it reduces the amount of plastic that gets returned with the overs into the composting process and that might eventually contaminate the compost. Particles of plastic grow smaller with each recycling and eventually pass through the screen. Second, overs piles are often so littered with plastic, they cannot be reused or even sold as mulch. In this case, air separation saves the costs associated with storing and landfilling the piles. It also recovers the organic particles for mulch or compost products.

The primary scourge of composting facilities is film plastic, derived from bags, packaging, plastic mulch and shrink-wrap. However, other plastic items also can taint the product including bottle caps, straws, eating utensils, beverage containers and plant pots. Typically, air separation systems are designed to extract the film plastic. Although many of the other items are removed with the film, the heavier plastics tend to escape.

The fact that plastic film easily floats in moving air has not been lost on facility operators. A walk along the perimeter fence provides proof enough. No doubt many operators have been faced in frustration, "If I can only figure out a way to blow the bleepin' plastic stuff out without creating a mess!" Well, a few operators have figured out a way. More recently, the concept has been developed into commercial equipment being used by the compost industry.

**Palm Beach County**

In 1995, operators at the Palm Beach County, Florida composting facility found an opportunity to reduce the amount of plastics accumulating in the composted screen overs. To control dust, the facility already had enclosed the outlet of the trommel screen by a metal discharge chute that directed the overs into a collection hopper of a stacking conveyor. The chute provided a means to channel air through the overs as they drop from the screen, removing plastic in the process (Figure 3). To create the airflow, a 110-amp variable speed exhaust fan was installed in the side of the chute below the screen. Louvers for the fan inlet opened about four inches into the chute so the overs actually fell onto the louvers. This had the effect of mixing up the overs particles, exposing more of the plastic to the air. As the overs continued to drop past the fan inlet, the air moving toward the fan picked up plastic film and other light particles. From the fan, the exhaust was pushed through a metal duct and into a roll-off container. The plastic settled out in the rolloff while the air passed out through a mesh-covered opening in the container (2 ft. by 2 ft.).

According to Pat Byers, manager of the facility, the system worked well. It removed nearly all of the plastic from the screen overs without experiencing problems, and at minimal expense. Nearly all of the components were fabricated or available on site. The fan was the type typically used for ventilating greenhouses. Because the exhaust air passed through the fan, plastic would gradually build up on the blades and housing and had to be cleared periodically. Byers believes that a turbine type fan would have eliminated this inconvenience.

Despite its effectiveness, the air separation system was only used for several weeks. At that time, the facility had started to change its methods for handling and sorting feedstocks (yard trimmings and biosolids). Emphasis was shifted to front-end separation so the need to pull plastic from the screen overs was reduced greatly. The facility also changed its screening plant (see "Processing Facility Retrofit at Florida Composting Facility," June 2001).

**Gilton Resource Recovery**

The composting facility operated by Gilton Resource Recovery in Modesto, California composes yard trimmings with a variety of food residuals from canneries and processing facilities. Many of the food residuals accepted are processed
AIR SEPARATION segregates light particles from heavy particles according to how easily the particles become entrained in a stream of air. The light particles go with the flow, the heavy particles don’t. It is often referred to as density separation because density is a primary factor determining whether a particular material becomes air borne. However, other particle characteristics also influence separation, especially the shape. A particle that does not have an aerodynamic shape, like a flat sliver of wood, might fly away in the air while other, rounder, wood particles slip through.

Actually, it is a quality known as the “terminal velocity” that matters. When a particle falls freely through a fluid, like air, the balance between gravity and the opposing friction causes the particle to fall at a constant speed — which is the terminal velocity. Terminal velocity is a quality of a particular particle, determined by its density and shape (and a few other factors like surface roughness).

The point of separation between “light” and “heavy” fractions depends on the velocity of the air stream. If the air velocity exceeds a particle’s terminal velocity, the particle is carried by the air. Since heavy (i.e. dense) materials have a large terminal velocity, greater velocities are needed to remove heavier particles.

Part of the challenge with air separation is that a class of particles, like plastics, can have a wide range of terminal velocities due to changes in composition, moisture, shape and orientation. To capture all of the particles in the desired light fraction, the air velocity must be set at the top of the light fraction’s terminal velocity range. Particles encompassing the heavy fraction — the stuff you want to leave behind — also have a range of terminal velocities. Making sure none of those particles fly away with the air means setting the air velocity below the low end of their terminal velocity range. If the terminal velocities of the light fraction and heavy fraction overlap, air separation becomes difficult. You cannot get good separation. This is why separating plastics from finished compost is difficult. In technical terms, the terminal velocities for compost particles and plastic particles overlap too much.

However, screen overs present a different situation. The overs are largely composed of large particles of wood, which have a substantially different density and size than plastic. The difference in the terminal velocities between the overs particles and plastic particles is large enough to get good separation. Still, some heavy plastics may remain behind with the overs, perhaps a plastic fork, while a few fibers of wood may wind up in the plastics bin.

Typically, air separation systems are designed to remove film plastic from screen overs. It is the screening step that separates plastic from the finished compost.

**Figure 4. Plastic separation system at Gilton Resource Recovery**

The system removes plastic from the inclined belt conveyor carrying overs away from the screen. The three-inch slot of the vacuum nozzle sits three to four inches above the conveyor surface. The nozzle spans the width of the conveyor and has the same trough-shaped contour such that the gap between the nozzle and the conveyor is the same across the width. The degree of separation is adjusted by changing the gap between the product on the conveyor and the nozzle. This is done by relocating the pin that attaches the vacuum assembly to the conveyor frame. A paddle-style blower located in the vacuum duct draws air into the nozzle, pulling up plastic from the belt. The air is then directed through an eight-inch flexible pipe into a debris box that collects the plastic and exhausts the air. While the vacuum system was installed on the existing conveyor, a vibration screen overs away from the screen. The system works so well that it spawned copy-cats at other composting facilities in the state.

**Commercial Equipment**

Because plastic has been such an annoyance to the composting industry, it was only a matter of time before equipment dedicated to the task of separating plastic from compost products would be developed. For several years, equipment companies made attempts at adapting existing equipment to capture plastic during or after screening, frequently by retrofitting screens. However, nothing worked completely to the indu-
Figure 5. Separation mechanisms for Hurricane system

- Suction fan with hose extracts light particles to covered container
- Overs from screen
- Vibrating input chute
- Optional high-speed sorting conveyor
- Head roller magnet
- Compressed air stream
- Clean end product
- Rock
- Ferrous metals

The Hurricane system uses several mechanisms to separate plastics from coarse feedstocks. In 2000, the Farwick Company in Oelde, Germany began selling a plastics separating machine called the Hurricane (Hurrican in Europe). It became available in North America in January 2001. As of this writing there are approximately 100 facilities using the Hurricane separator worldwide. The cost of the separator is about $100,000.

The Hurricane removes plastic from coarse feedstocks, like screen overs, and can also perform other separation tasks. It incorporates several mechanisms in its operation, with air separation being a key element (Figure 5). Following screening, overs are fed by an external conveyor onto the input chute — essentially a sloped stainless steel deck about four feet wide that vibrates. As the overs vibrate toward the belt conveyor, the material spreads out and plastics are exposed.

From the chute, the overs drop onto an inclined belt conveyor that is shrouded by a metal hood. The space between the chute discharge and belt conveyor serves as an inlet for the airflow. A blower fan, located between the base of the input chute and the conveyor, pushes air through the overs as they drop. The air picks up plastics and other light particles and then continues through the belt conveyor hood to a suction fan near the top of the conveyor. The suction fan gathers the plastics-laden air from the hood and moves it to a discharge container where the plastics are captured. Various discharge devices can be used including mesh bags and roll-off containers with a screened vent to exhaust the air.

After passing the suction fan, the overs can be discharged or delivered to another optional sorting step. In this step, the overs are deposited onto a sloped high speed inclined conveyor that removes heavy objects, like rocks and golf balls. The rocks roll down the conveyor slope while the mostly-organic fraction is conveyed up the slope and discharged. Magnets can be placed along the conveyor to remove ferrous metals.

The machine can be adjusted in several ways to produce the desired degree of separation. The height of the suction inlet above the belt can be changed to pull more or less material off the conveyor. This is normally the first adjustment to be made. The speed of the blower also is adjustable. In addition, the slope of the input chute can be changed to alter the feed rate and initial segregation of plastics.

According to Chris Valerian, vice-president of Norton Environmental Equipment and the exclusive marketer of the Hurricane in North America, the machine is meeting expectations. "Although isolated pieces of plastic can escape if impaled on a stick of wood or trapped within a clod of wood chips, nearly 100 percent of the plastic will be removed from composted screen overs," says Valerian. "To accommodate the changes in material moisture content, the machine is adjustable." He adds that the optimum application is for screening finished product. "This minimizes the amount of stringy material, typically found on immature product, where plastic can be trapped."

Because this equipment is fairly new, it hasn't yet established a substantial track record. However, experience at composting facilities to date is encouraging. For example, the large yard trimmings composting facility in Islip, New York is testing the equipment to remove the remains of plastic bags from its screen overs. The facility will determine whether to purchase the equipment based on established performance criteria.
The equipment will be evaluated according to its separation efficiency at various moisture contents and levels of contamination in the overs. As of this writing, the tests are still in progress but the preliminary results are promising, according to Stuart Buckner, Director of Environmental Services for the town of Islip.

One of the more experienced facilities with air separation is County Conservation in Sewell, New Jersey. The facility, which composts a mix of yard trimmings, had accumulated approximately 20,000 cubic yards (cy) of plastics-contaminated screen overs. John Petrongolo, the site manager, says that they have tested several schemes to remove the plastic from screen overs including multiple screening and attaching an 18-inch vacuum hose to the deck of a star screen. While the vacuum pulled off much of the plastic, its performance was inconsistent and sensitive to the compost’s moisture content. In the end, the repeated screening only increased the percentage of plastics in the remaining overs.

The facility started using the Hurricane in January 2001. "It is the most effective method of removing plastics from our overs that I have seen so far," Petrongolo says, adding that nearly all of the plastics are captured. Primarily, what remains in the overs are a few heavy plastic items (e.g. plastic toys) and large pieces of film that get trapped within the overs particles. Since acquiring the machine, the overs pile has been reduced to 1,000 cy. The organic material recovered from the overs has been re-ground and sold as mulch.

One Weapon In The Plastics Battle

Air separation is getting more attention in the battle to remove plastics from compost products. It will likely become more useful as operators gain experience and equipment manufacturers find new applications and refine their techniques. And the composting industry appears to be eager to give the technology a chance. For example, two of the 16 recycling grants that the state of Massachusetts awarded in 2001 were for air separation equipment.

However, air separation is just one weapon in the arsenal to manage plastics contamination. As it currently works, air separation is limited to cleaning up screen overs. While this certainly has value, it is only one phase of the production system. To substantially eliminate plastics from compost, other management practices must be part of the system including source separation, bio-degradable bags and packaging, front-end sorting, proper size reduction and screening.

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