Controlling And Preventing Fires At Compost Facilities

An inherent challenge of dealing with organic materials is potential flammability. What are the best fire prevention and control strategies? Several operators discuss what works for them — and what doesn’t.

David Riggle

The last thing Sharon Barnes wanted to cope with this past winter was a fire. Nevertheless, on February 26, 1996, workers at the Barnes Nursery Composting Facility in Huron, Ohio noticed smoke coming from a 30 foot high pile of two-inch woodchips in the stockpile area. Although Barnes Nursery’s experience with fires was new to them, it’s not uncommon. “Calling around the country for advice on handling with our situation, we found that many compost and mulch facilities have had to deal with fires,” says Mike Dresser, manager of Barnes’ yard trimmings recovery division.

In researching this article, BioCycle discovered that there are a number of approaches to fire control and prevention that are “empirically driven,” as one operator put it. The strategies are based on localized considerations such as climate, materials, available equipment and whether the fire was started by an external spark or internal spontaneous combustion. Interestingly, seeming contradictions in methods often can be explained by site specific variations. “There doesn’t seem to be a clear consensus of opinions on preventing or managing chip fires,” says the manager of a wood processing facility, “and what works in one situation may not in another.

Workers at Barnes Nursery in Ohio tried using a loader to isolate smoldering chips and later doused the pile with water cannons. The fire burned for over a month.
Whatever works for you, it's important to remember that this is a common problem and that fire control and prevention need to be addressed at any facility which is handling these materials.

The Ohio Smolder

"As soon as we saw the smoke, the fire department was notified," says Sharon Barnes. "After discussing the alternatives, we decided to use a D7 Caterpillar Dozer, two-wheel loaders and other equipment to knock down this mountain of burning chips, spread out the burning material, isolate the fire and let it burn itself out. It seemed best to manage it that way since the nearest hydrant was a quarter mile from the site, it was winter and the smoldering fire didn't pose any threat to people or property.

The wood chips — generated by the company and other tree service operations — are stored immediately adjacent to the composting facility and nursery operation on a two percent sloped, compacted clay base. As trucks drop off the chips, they are pushed into one of several piles. What began to smolder was the largest pile on the site — a mixture consisting of both old and new material.

Although the plan to manage the fire seemed logical and simple enough, it turned into more of a headache than anyone expected. "We used the company's 2,000 gallon water trucks to put water on the fire as it was moved around by the bulldozers," Barnes says. "After three days of breaking apart the pile, the fire was isolated into one area. Smoldering continued for three more days with the odor causing more than a nuisance to our downwind neighbors. We again brought in equipment to further isolate the fire and applied more water. We thought that was it, and for several days there was no sign of smoke, but then it appeared again out of the ashes of the original smoldering area."

With that discovery, the company again moved the material around, added more water, and saw the area blanketed in a foot of snow. "No matter what we did, the wind and internal conditions in the pile seemed to keep generating smoldering areas," Barnes says.

Mike Dresser explains that the weather contributed to the outbreak of fire. "The wood chip pile normally heats up to a certain extent," he says. "On any given day, especially in the winter, you could see steam coming out of the top of that pile. However, in January of this year, we had a big rain and then a hard freeze that actually encapsulated the pile so the heat couldn't escape. According to the fire chief, spontaneous combustion could actually have started the smoldering as early as December, even though it wasn't brought to the surface until February."

Dresser also notes that when the pile was broken open, they were able to see the depth to which snow and water penetrated — and it wasn't very far. "The frost ended about two feet into the pile," he says. "Rainwater just rolled right off the frozen surface. Underneath that two foot shelf, the material was bone dry."

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In this case, the most effective way to handle the fire turned out to be breaking into the pile, isolating the smoldering sections, spreading them out in a thin layer, and only then using water. Barnes also reports that applying a clay soil or subsoil layer on top of spread out, burning wood chips helps to smother the fire and reduces odors.

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MINIMUM ignition temperatures for organic materials vary depending on a number of physical and environmental conditions, but roughly range between 250°F and 400°F or more. That's a big jump from the approximate peak composting temperatures of 170°F to 180°F resulting from heat output through respiration due to biological decomposition. Why do internal pile temperatures sometimes continue to rise, even after biological heating has stopped?

"What appears to happen," says Roger T. Haug of Environmental Engineering Associates in El Segundo, California, "is that there is a fairly significant rate of chemical oxidation which, at more normal temperatures, is just too slow to be really discernable. So, if the material is dry enough, well insulated, and the air flow is such that it's feeding the chemical oxidation but not so high as to remove too much of the heat, you can get an increase of temperature within that material up to the point where it then starts smoldering — and can catch fire if it gets enough oxygen. The same kind of things happens with industries handling sugar, evaporated milk and similar materials. The basic principles are the same."

Robert Rynk at the University of Idaho agrees with Haug's explanation and points out that the best guidance on what happens during spontaneous combustion comes from outside the composting field. "To understand whether or not you're going to get a fire, look to literature on hay and silage," says Rynk. "It suggests that chemical oxidation begins at around 130°F, and biological activity raises the temperature to the point where the chemical reaction begins to happen faster. Biological action is needed to initiate the chemical reaction which causes spontaneous combustion."

Moisture is a critical factor. "If the material is very wet, you won't get spontaneous combustion," Rynk adds. "In that case, it would contain enough moisture so that any rise in temperature is accompanied by evaporation. It's self-regulating. If materials are too dry it won't happen either, because the biological action is inhibited, which is why hay is dried down before it's put in the barn. However, if the material is in a range somewhere between 25 and 45 percent moisture, spontaneous combustion is possible."

Haug also suggests that operators keep a close eye on both moisture content and temperature of materials they are handling. "I've never heard of a fire problem with material that is around 40 percent moisture and above," he says. "However, if temperatures are rising above 180°F and the materials are between 20 percent and 30 percent moisture, I would say that you're definitely getting to a real problem stage."

Guidelines like these are only approximations, as both Haug and Rynk point out. Other scientists note that — specifically in hay — spontaneous combustion also is significantly affected by factors such as relative humidity and air flow rate.

Understanding the differences between heat generated through biological or chemical means can have far reaching implications for facility safety. "Operators of compost facilities are told that if your process is running hot, it needs more air," says Haug. "If it's running cool, the heat is being removed too fast so you want to reduce the air flow. There are computerized temperature control loops that follow the logic that if the temperature is too high, the fan should be increased. That works extremely well, as long as it's the heat of biological oxidation that you're dealing with. If a smoldering situation exists as a result of chemical oxidation, increasing the air is actually the wrong thing to do, because you only will be stoking the fire."

Haug emphasizes that every compost facility should have a fire plan. "Any time there is that much organic material in one place, there is, almost by definition, a potential for fire."

The most practical and efficient method of fire prevention management for our operation will be to windrow the material in eight to 12 foot high piles, each 18 feet wide," says Sharon Barnes. "There are a number of reasons we favor windrows over piles in our operation at Barnes Nursery, to prevent a situation like this from reoccurring. After talking with Dr. Harry Hoitink at Ohio State University, the company developed a storage piles is to use a layering technique that builds the height of a pile slowly rather than all at once. "What some paper mills and wood processing facilities do is only raise the pile by a foot a month at the most," Hoitink says. "That gives the bark or wood chips time to stabilize before adding more material. Then biological activity in the pile stays low enough, and the heat output doesn't get high enough to elevate the temperature to where you end up with a fire."

"If you dump it in a big pile all at once, the heat output — and it all depends on the material — raises the temperature quickly to between 140°F and 170°F or more (60° to 80°C). Some tree barks have low flashpoints, so it is possible to actually get a fire with relatively low temperatures, whereas with other materials it's much higher. Knowing the characteristics of the raw materials involved is important. Even so, there still may be a fire now and then, but for the most part, the layering method has worked successfully for decades."

Mixed Feedstock Fires

"It really is mind boggling to try to analyze and separate materials to prevent fires," says Doug Porter, manager of Western Organics in Phoenix, Arizona. "The problem that we've run into is that all organic materials will burn. There are a combination of factors that influence when a fire is more likely and, when the environment is just right, a fire can get started through internal combustion or external causes like a spark from a truck exhaust."

Western Organics' 30-acre Phoenix facility composts yard trimmings, sawdust, bark, recycled gypsum, pallet waste, vegetable residuals, animal bedding, paper mill sludge and manures. Between 300,000 and 350,000 cubic yards of feedstocks are ground, composted in windrows, screened, bagged and screened.
shipped to market each year (see “The Life and Times of A Wood Recycling Company,” BioCycle, April, 1996). In addition, a total of 120 acres in five other Arizona locations also are used for composting, staging and shipping of bulk products.

As for combustibility of specific materials, Porter notes that, without a doubt, the fresher feedstocks cause the most problems. “It’s in that virgin, unprocessed material, always,” he says. “Once the incoming organics are ground to half-inch minus and moisture is up to the proper level, we don’t have fire problems, and it doesn’t matter if it’s sawdust, bark, green waste, straw or horse bedding.”

Fighting Fires In Phoenix

Working in such a “combustible environment,” as Porter calls it, has provided Western Organics with ample practical experience in dealing with windrow and storage pile fires. “The first thing we’ve determined,” Porter says, “is that the hardest fires to combat have been in materials with a particle size of four inches and above. Because there’s so much air space in a pile like that, it’s very difficult to smother the same or like material to smother it. We’ve also learned that applying water does very little, because the surface usually is bone dry and repels water. I’ve seen sparks glowing red hot floating right out across a flood of water that’s a foot deep. Water does help if you use it to saturate some product that is not yet burning, because it wets the surface and prevents some of the wind blown sparks from igniting a new pile. But that’s about it.”

Steve Miller, yard manager of Western Organics’ Phoenix facility, agrees with Porter’s techniques — and the conclusions reached at Barnes Nursery in Ohio. “Water doesn’t put it out, but actually seems to make it hotter, and it just continues to burn,” he says. “What we will do is take a good couple of feet of material that’s not burning off the top and sides of the pile and roll it right onto the fire. That will smother it and bring it under control a lot quicker. Then we’ll put water on the smoldering section to form a crust. The next step is to go back and screen the material around where the fire was to get all that hot feedstock out of there to eliminate the hot spots. Otherwise it’s a never ending battle.”

Miller adds that screening hot material will not destroy the equipment as long as the process is monitored carefully. “Once you’ve smothered the fire, there won’t be any flames, but there still will be hot spots. You don’t want to put a full bucket of flaming material into the grinder or screener, but hot stuff is O.K. We’ve found that when you shrink the particle size, it takes away a lot of the air space and that makes future fires less likely.”

Grinding also has proven to be a useful technique when other equipment isn’t available. “Here in Phoenix, we’ve got six loaders, a dozer, water wagons and sprinkler hoses. We’re pretty well equipped to put out a fire,” Porter notes. “At our operation in Heber, we don’t have the equipment to go in and smother the material on the spot so we sometimes will use grinding as a fire management option.”

In such a dry and windy environment, the importance of wind direction is critical. “The biggest thing in fighting a fire is to keep the wind at your back,” Miller notes. “Don’t ever push into the wind. I’ve seen guys do it and it’ll just set your machinery afire.”

Shaping Piles For Fire Prevention

Once moisture has been added to a windrow and heat is being generated, the risk of fire increases, especially when there are high winds. To help combat those risks, Western Organics tries to dome their piles. “That way there aren’t any sharp edges so the wind blows over and doesn’t penetrate,” Miller says. “I also use a bulldozer and will drive it up over the piles to help push out air pockets. If I can keep the air out, keep the pile in shape and then rotate the material — keep moving it around so it doesn’t superheat — I have a lot less trouble.”

The smaller particle size favored by this operation fits in with the construction of smooth, compact piles. However, it also helps from a materials handling perspective when a fire starts. “The goal we’ve had here in Phoenix is to have a program that reduces all four-inch and above material on a monthly

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basis," explains Porter. "If you are bringing in larger sized material - along with green waste, branches, tree limbs and so on - it is very difficult to roll with a loader. Traditionally in our business, an operation will have an eight to 10 yard bucket loader on hand, and if you drive that across the surface of a pile to move some material to try and bury a fire, you can't roll it. It just balls up like straw underneath you. That's why we try to get it down smaller. At four inch minus, you can get a good bucket full and use it to contain or smother an existing fire on the same pile."

Case Study in Albuquerque

In May, 1995, the City of Albuquerque, New Mexico's composting facility experienced a troublesome fire that started in the open air materials storage area and then spread to other windrows. The way the fire initially was dealt with, and how it eventually was brought under control, demonstrate the effectiveness of the methods employed at Western Organics.

The City's operation - called the Pilot Composting Facility (PCF) - includes a 137,000 square foot enclosed composting building, 51,000 square feet of exterior covered area (roof but no walls) at the north end of the building, and a 40,000 square foot open air storage area for incoming materials. The facility handles around 16,000 tons per year of mixed feedstocks, including 9,700 tons of biosolids, 3,600 tons of horse bedding and stable waste, and 2,500 tons of yard trimmings. The plant provides compost in exchange for raw materials from several sources, such as the City's Parks and General Services Department, the University of New Mexico, Kirtland Air Force Base, and Albuquerque Public Schools.

Last spring, an approximately 15 foot tall and 50 foot square pile of horse bedding and yard trimmings from city sources caught on fire. "There was an intermix of dry and damp material in the horse bedding, so it wasn't homogeneous," says Steve Glass with the City of Albuquerque. "Some of the damper pockets with horse manure really heated up because of thermophilic activity, and then the dryer areas nearby began to smolder. Unfortunately, the structure of the pile just aggravated matters. It's windy out here in the spring, and the pile was built up very tall with steep, sloping sides. In other words, we didn't build it so that either it was insulated from the wind or so that the wind could skim over the top. It was constructed so that the wind would actually penetrate into the pile very deeply."

Advice From A Wood Recycler

DOWNSIZING, grading and screening land clearing debris and other woody materials is a specialty of Rainier Wood Recyclers in Kent, Washington. The company's two primary grinders are capable of handling between 500 and 800 tons of material per day, according to general manager Bob Sargent. Rainier expects to be at about 90 percent capacity in 1996. End products typically are sold for pulp, fuel or landscaping. At the BioCycle West Coast Conference in March, part of Sargent's presentation focused on his company's experiences with fire prevention:

"Wood chips definitely can get hot," he says. "And a fire is something that happens — once — to a lot of people. Back in 1986, we lost a pile. It smoldered for several weeks. Although it never did burst into flames, it charred and ruined the chips. Apart from the loss of product, we have high voltage power lines overhead at one of our sites, so we simply cannot afford to have a fire in our chip pile, and wood waste recyclers have a history of fires. Because of that, we manage our materials carefully and have come up with a strategy that has kept us from having any kind of fire for the past 10 years.

"Rainier Wood Recyclers does not compost, or at least we try not to, but composting is useful to understand. In fact, the best way to not catch a land clearing debris chip pile on fire is to first learn how to compost. Then do everything exactly the opposite from what you are supposed to do to get a pile hot. The most important consideration is to reduce the amount of biological activity in the pile. Primarily that means limiting the amount of green material. There's much debate over what catalyzes a fire, what gives it the spark, but I think the precursor to it all is the biological heating of a pile. It's like a prewarmer. If you can keep the pile from preheating in the first place, then you think you've gone a long way to preventing a pile fire.

"If you intend to store wood, the best way is in its raw form — as whole stumps, brush, pallets or two-by-fours. If possible, let it dry like that, until any green vegetative material is gone. If we're going to store something for six months, we simply stack it as it comes in off a truck. We won't grind it until just before we ship to market.

"If that isn't possible — say when we haul in material from job sites that are a long way from our facility — we will chip it to as coarse a size as possible so that air can pass through the piles to keep them cool. If you get too many fines in a chip pile, it seems they become a kind of insulation blanket that keeps the heat in. With coarser wood chips, you have more aeration. Typically we will load these piles as high as our large excavator will reach, which is around 18 feet.

"We also don't drive up onto the pile with a front-end loader or bulldozer. That just compacts the material, pulls in heat and prevents air from getting in to cool it off. I've also heard that it's a good idea to keep metal out of the pile because it can attract heat, although I've never experienced that myself."
Big Chips, Small Chips

SORTING OUT seemingly conflicting operators’ advice on fire prevention and control may not be as difficult at it might appear. For instance, one immediate discrepancy appears to be the optimum size of wood and bark chips for storage. Bob Sargent of Rainer Wood Recyclers suggests that if you have stored material, chip it as coarse as possible and don’t compact it, thus allowing air to pass through and keep it cool. Doug Porter of Western Organics, on the other hand, suggests a strategy to keep the wind out by shaping smooth, compact piles and grinding all material to four inch minus size (which also makes it more useful for smothering a fire should one occur).

Some differences can certainly be attributed to variations in climate at each operation. Beyond that, however, there are conditions under which both strategies are correct. Basically, it seems to depend on the specific materials being processed and their thermophilic status.

Doug Hanchett, plant manager for Western Organics in Albuquerque, provides some insight: “First of all, we’ve found that there is more likely to be a problem in piles that have just started composting — it doesn’t matter whether it’s a pile with biosolids and wood products, bark and manure or yard trimmings. Grass is the worst as far as I’m concerned because it can get hot so quickly. It can make beautiful compost, but if not taken care of properly and put into windrows, or even into bulk storage piles with leaves and other carbon sources, you’re looking for a fire. So piles that are heating up are the ones we really have to watch.

“Next, when storing — not composting — a product like bark, we don’t seem to have much of a heat problem with medium and larger sized chips unless the pile is very large and the wind starts driving into it. The heat seems to dissipate a lot easier.

“Bark chips smaller than an inch-and-a-half down to sawdust, on the other hand, can get hot in a matter of seconds. It can be stone cold, but if there’s moisture and you put it in a storage pile it just starts heating right up. So if that’s the size of some incoming material, we will try to keep it very well compacted to prevent oxygen from getting into the pile and causing the heating process to start.

“We want to control when we compost a pile. When it’s time, I want to take it out of the big stockpile over to a windrow, and then I want it to cook. But while it sits in that big pile, I don’t want to start the composting process, because I don’t want it to catch on fire. When a pile starts getting too hot — unless you can control that in some fashion through shape or moisture or smothering — it just will go from bad to worse. The hotter it gets, the more air it sucks from the bottom, the more hot air goes out the top, and the more likely it is that a fire will start.”

Whatever it landed on. The fire worked its way downwind, and then started going cross wind behind our building where it was insulated from direct wind contact but had plenty of air to keep burning. By that time, the city and county fire department had been called. Something like 17 vehicles and 60 personnel eventually showed up over a week to two week period trying to control this thing.”

Doug Hanchett, plant manager for Western Organics in Albuquerque, also was called in to give advice. One reason was that some of the other piles the fire spread to consisted of feedstock obtained through an exchange agreement with Western Organics — screened horse bedding from a racetrack and grass from the State fairgrounds, and a mixture of straw, sawdust, bark and wood chips called “hog overs.” Additionally, the city needed to utilize Western Organics’ knowledge in dealing with this kind of fire.

“At first, the fire departments were using structural approaches to fire control, which basically means opening it up and pouring water into it,” says Glass, “but we learned that opening it just allows the wind to spread the fire. Instead, you need to contain it within the pile. Western Organics suggested just starting to whittle away at the outer perimeter of a pile that’s on fire inside. When you have pulled away all the unburned material and isolated the area that’s smoldering in the middle, then you can apply water.”

Glass also notes that close monitoring is critical because — even if a smoldering area has been isolated — the fire often will find a way through the middle of the pile and pop up somewhere else. Unfortunately, we discovered that what burns best are the nice, clean organics,” he says, "not the unscreened incoming material that includes stones and trash and wire and things you don’t want, even though that’s where the fire originated. We ended up with all that garbage and lost all our good stuff." Since the fire, the PCF has been building its storage piles longer and lower, and locating more of them on the East side of the building to help provide insulation from the prevailing westerly wind.

Other operators with experiences dealing with fires at composting facilities are encouraged to share them for inclusion in a future article on this subject. Please send to “Fires”, BioCycle, 419 State Ave., Emmaus, PA 18049. E-mail: biocycle@aol.com.