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February, 2008
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ADVANCING COMPOSTING, ORGANICS RECYCLING & RENEWABLE ENERGY
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Managing Storm Water

Is it storm water? Is it wastewater? What is the best method to calculate flows at the site? These questions, and more, are answered in *BioCycle*'s new Operator Insights feature. Part I

Craig Coker

ONE OF the clearly recognized benefits of compost when used as a soil amendment is its ability to increase the water holding capacity of the soil. This is due to the ability of compost to retain water. Yet, this same beneficial material, while being manufactured, is now believed to create water quality problems that require regulatory permitting and potentially expensive treatment systems. Unfortunately, there is a wide variety of state regulatory approaches to address this issue; some regulate storm water runoff from composting pads as a wastewater, and some regulate it as storm water.

The purpose of this two-part article is to examine how storm water is produced at a composting facility, what types of contaminants it might have, how is it being regulated and what types of treatment work to meet regulatory requirements. As a former composting facility operator and state organics recycling coordinator, and now as a consultant, I have worked first-hand on calculating storm water flows, identifying pollutants, and determining the optimum management strategy. Those lessons learned are reflected in these articles.

Part I also kicks off a new *BioCycle* editorial feature in 2008, "Operator Insights." Appearing in every other issue, Operator Insights will examine topics that site managers face in their daily operations.

Taking a manual grab sample of runoff (left) at the wrong time may result in pollutant concentrations that are not truly representative. Sampling methods to offset this difficulty include flow-composite and time-composite samples, often collected with automated sampling equipment (above).

WHAT'S THE PROBLEM?

In a nutshell, contamination. By virtue of some of the data collected in annual storm water runoff monitoring requirements on composting facilities — imposed under the Phase 1 National Pollutant Discharge Elimination System (NPDES) program established in the 1990s — it is now apparent that rain falling on exposed composting windrows can pick up substantial amounts of pollutants. If discharged to receiving streams unmanaged, the pollutants have the potential to cause water quality problems in those streams. These off-site losses present a higher level of concern than a similar amount of the same compounds in the compost itself because water quality standards for some constituents (i.e. pesticides, metals) are set at much lower levels than any standards for land application of compost containing these compounds and elements (Cole, 1994).

Not surprisingly, the constituents in composting pad storm water runoff depend, to some extent, on the feedstocks being composted. Yard trimmings composting facilities have long been thought to have the least potential for contamination due to the relatively clean nature of the feedstocks, i.e., least amount of chemical and pathogenic contamination to start with (relative to manure, biosolids and food scraps). Yet

runoff from these facilities has been shown to be highly variable, containing potentially significant levels of nutrients, soluble salts, Biological and Chemical Oxygen Demand (BOD/ COD), tannins and phenols from decomposing leaves, herbicides, pesticides, fungicides and fecal coliform (probably from animal feces mixed in the yard trimmings). Animal manure, biosolids and food scraps composting facility runoff will likely have higher levels of nutrients, organic acids produced during decomposition and fecal coliform bacteria (Oregon DEQ, 2004). Little data is available on other pathogenic microorganisms in composting facility runoff.

Potential impacts of these constituents on stream and river water quality are the same as, and in some cases more severe than, untreated discharges of sanitary wastewater. BOD and COD exert an oxygen demand on the dissolved oxygen in water, which if depleted will cause significant aquatic ecological mortalities. Widespread fish kills are the most obvious of these problems. Nutrients contribute to the geomorphologic process known as eutrophication, where nutrients support the growth of algae, which also deplete oxygen upon their deaths, as well as stimulate the growth of vegetation (this is an acceleration of the natural process by which shallow watercourses become swamps, and in turn, eventually become dry land). Tannins and lignins are natural dissolved organic acids that give water the characteristic color of compost tea. Phenols are a group of related acidic compounds that are hydroxyl derivatives of aromatic hydrocarbons. These include such substances as cresol, catechol, quinol, xylenol, guaiacol and resorcinol. There are two effects apparent in phenol-contaminated waters: toxicity to aquatic life and the generation of an unpleasant taste in fish and shellfish.

There are different sources of water contributing to runoff from a composting facility and each is subject to different levels of potential contamination. Ordered from most to least potential for contamination, they are: leachate, process storm water, nonprocess storm water, wash water and run-on. "Runoff" is generally a mix of leachate, process storm water, wash water and nonprocess storm water. Each has different characteristics, as defined below, and should be managed to prevent potential environmental harm.

In most composting piles, water moves to the bottom under the influence of gravity and creates *leachate* if the moisture content of the compost exceeds its water holding capacity (Krogmann, 2000). Moisture content in a pile is affected by feedstock types, mixing procedures, incoming rainfall, decomposition rates of organic matter that release the water bound inside plant and animal cell walls, the presence or absence of forced aeration that tends to evaporate more moisture and whether the composting process uses supplemental irrigation during active composting. A more coarsly textured mix, like yard trimmings, will have less water holding capacity than a more finely textured mix, such as dairy manure bulked with sawdust. Leachate draining through a composting pile will pick up soluble materials (tannins, nutrients, salts) as well as small particulate matter created by the decomposition process. It is a combination of the tannic acids and the particulate matter that give leachate its characteristic dark brown color.

Process storm water is precipitation that falls on the site and contacts the composting material without flowing through the pile. This includes runoff from the sides of the pile as well as storm water that comes in contact with waste material and compost that has strayed from the pile. *Nonprocess storm water* is precipitation that falls on the compost site, but that doesn't come into contact with wastes or compost. *Wash water* is generated by washing vehicles and equipment and contains materials dislodged from vehicle wheels and bodies, but the concentrations tend to be lower due to the high volumes of dilutive water used in washing. On the other hand, wash waters can contain surfactants and other chemicals from any washing detergents used. *Run-on* is rainfall runoff from uphill of the composting site that flows through the site and comes in contact with wastes or compost. Enclosed composting facilities also have condensate — water that evaporates from the compost and condenses on cooler surfaces such as building walls.

HOW MUCH RUNOFF?

Figuring out how much storm water runoff will have to be managed at a composting facility is not an exact science. Rainfall varies in intensity both in space and in time, as evidenced by the intensity of a thunderstorm on one side of a road, but not on the other. Similarly, runoff quantities vary as a function of how much rain has fallen recently, possibly saturating the ground, as well as constructed conditions like composting pad construction materials; presence, orientation, spacing and age of windrows; and moisture content in those windrows. A 2004 Canadian study concluded that about 68 percent of the incoming rainfall became runoff at windrow composting facilities, and that there was a significant delay between rainfall and runoff as the compost detained the rainfall and released it slowly over a period of one to two days (Wilson, 2004).

Quantities Of Storm Water

There are several tools of hydrology and hydraulics available to calculate runoff quantities from various storm events. Storm water management regulations and programs have historically been focused on managing *quantities* of storm water. These rules are often based on what is called the "recurrence interval" of a storm; terms such as "25-year, 24-hour" and "10-year, 1-hour" storms are often used.

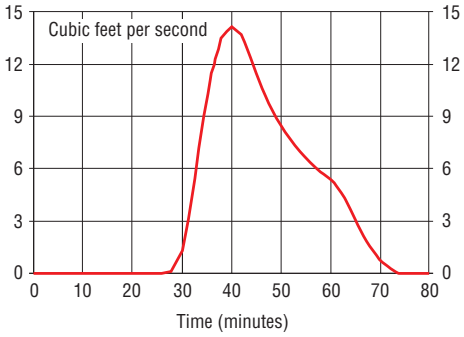
The recurrence interval of a storm is a statistical abstract, and mathematically is the inverse of its probability of occurrence in any given year. For example, a "25-year" storm has a statistical probability of occurring once every 25 years (the inverse is 1/25, which equals 0.04, or 4 percent). Thus the 25-year storm has a 4 percent chance of occurring in any given year. Similarly, a 10-year storm has a 10 percent chance of occurrence and a 100-year storm has a 1 percent chance of occurrence. It is worthwhile to note that these statistical abstractions can be misleading. Many people think that if a storm has only a 4 percent chance of occurring (i.e. once every 25 years), it is unlikely to occur more frequently. It is entirely possible that two 25-year storms can occur in the same year, or even in the same week or month.

A "24-hour" storm is the total amount of precipitation that falls in 24 hours, which, for example, is 6.5 inches here in western Virginia. Similarly, a one-hour storm is the amount of rain falling in one hour (about 2.2 inches here). However, storm water management systems are based on both *volumes* of storm water as well as *flow rates* of water to be managed, so a storm of one hour duration with a rainfall intensity of 1.5 inches per hour will produce the same volume of rain (1.5 inches) as a storm of six hour duration but only one-quarter inch/hour rainfall intensity. That 1.5 inches of rain will produce a volume of 54,450 cubic feet of rainfall (about 407,000 gallons) on a 10-acre concrete or asphalt composting pad. Not all of that rain becomes runoff.

Flow rates are measured in volumes per unit of time (for example, cubic feet per second, or cfs). Flow rates of runoff from a storm vary over the duration of the storm and are characterized by hydrographs, which plot the change in runoff flow rate over time for a given storm. Figure 1 is a runoff hydrograph for a 10-year, 1-hour storm of 2.2 inches/hour falling on 13.25 acres of gravel compost pad draining to a pond. This storm will produce a peak discharge of 14.13 cfs and a runoff volume of 18,274 cubic feet (136,690 gallons).

Figure 1. Royal Oaks site peak runoff

Runoff hydrograph for a 10-year, 1-hour storm of 2.2 inches/hour falling on 13.25 acres of gravel compost pad draining to a pond



Calculating A Runoff Curve Or Coefficient

Figuring out how much of the rain falling becomes runoff to be managed in a storm water system requires an estimation of the absorptive capacity of the surface onto which that rain falls. In a forested watershed, rainfall is intercepted by leaves and infiltrates into the ground, so only a portion becomes runoff that reaches streams. In an asphalt parking lot (or composting pad), little is intercepted or infiltrated, so most of it becomes runoff (but not all, as even asphalt or concrete will intercept small amounts of rain in surface irregularities).

Dimensionless numerical coefficients have been developed to represent different surface conditions affecting runoff. The exact number used depends on the method of hydrological analysis — whether it is hydrograph-based or nonhydrograph-based. Table 1 presents runoff coefficients for different land uses (or "cover types") for both nonhydrograph methods and for hydrograph-based methods (Virginia DCR, 1999). Generally speaking, land uses that have higher amounts of impervious surface have higher runoff coefficients, reflecting that more of the incoming rainfall is being converted to outgoing runoff and less is lost to interception and infiltration.

Hydrologic soil groups are assigned by the U.S. Department of Agriculture and reflect the "runoff potential" of a particular soil. For example sandy soils tend to be in Groups A and B (see Table 1 categories), while clayey soils tend to be in Groups C and D, which have higher runoff potential.

Calculating a runoff curve number or coefficient for a composting pad requires use of a weighted average approach (weighted by the percentage of the pad occupied by windrows and the percentage not covered with windrows). The total square footage of the pad occupied by windrows has a lower value than the total square footage of the pad between windrows. Not all composting windrows have the same runoff coefficient. Drier compost, subject to summer temperatures and lighter rain intensity, would likely result in a lower measured runoff coefficient. For an asphalt composting pad, assume a coefficient of 0.85 for the aisle spaces between windrows. For the windrows themselves, assume a coefficient between 0.50 and 0.70 (Kalaba, *et al*., 2007).

The most widely used nonhydrograph method for calculating runoff is the Rational Method. It was developed in 1889 as a method for calculating peak flows for sizing storm drains:

$$Q = C \times I \times A$$

where Q = maximum rate of runoff, in cubic feet per second

C = a dimensionless runoff coefficient (see Table 1)

I = the design rainfall intensity, in inches per hour, for a duration equal to the time of concentration of the watershed

A = the drainage area, in acres

The term "time of concentration" refers to the time it takes for runoff to move from the most hydrologically distant point in the drainage area to the point of interest, such as the inlet to a storm pond, a flow monitoring station on a stream or the design location for a new impoundment. For paved composting pad runoff calculations, time of concentration is measured in minutes, provided upgradient runoff is properly diverted around the pad. For natural watersheds, time of concentration is measured in hours.

There are a number of limitations with the Rational Method in determining runoff volumes and flow rates: it assumes the duration of the design storm is equal to the time of concentration in the drainage area; it fails to account for the fact that compost windrows can shed rainfall, absorb rainfall or act as a reservoir and detain rainfall; and it assumes that the fraction of rainfall that becomes runoff is independent of rainfall intensity or volume (with windrows of compost, runoff varies with rainfall intensity), along with others (Kalaba, 2007).

Using the Rational Method on the same composting facility illustrated in Figure 1 (i.e. drainage area = 13.25 acres, rainfall intensity = 2.2 in/hr) and assuming a weighted runoff coefficient of 0.75, the calculated peak discharge rate is 21.86 cfs, a 54 percent overestimate compared to the more rigorous and accurate hydrograph method shown in Figure 1. This might have resulted in expensive overdesign of a storm water management system.

Developing an accurate natural hydrograph of a storm event requires extensive real-time flow monitoring. Given the cost and difficulty of real-time monitoring of small watersheds, synthetic unit hydrographs were developed by Snyder in 1938 to establish a method of simulating a natural hydrograph by using watershed parameters (area, shape, slope and ground cover) and storm characteristics. The synthetic unit hydrograph method is the cornerstone of the hydrologic work done by the USDA's Soil Conservation Service (now the Natural Resources Conservation Service), embodied in the *National Engineering Handbook*, Section 4, Hydrology (1985) and in widely-available computer models like TR-20, "Project Formulation, Hydrology" (1982) and TR-55, "Urban Hydrology for Small Watersheds" (1986).

TR-55 presents two general methods for estimating peak discharges from urban watersheds: the graphical method and the tabular method. The graphical method is limited to watersheds where runoff characteristics are fairly uniform

Table 1. Runoff coefficients

Nonhydrograph Method Rational Method Runoff Coefficients		*Hydrograph Method Runoff Curve Numbers for Urban Areas*				
			Hydrologic Soil Group			
Land Use "C" Value		*Cover Type*	*A*	*B*	*C*	*D*
Business, industrial and commercial	0.90	Paved parking lots	98	98	98	98
Apartments	0.75	Paved streets	83	89	92	93
Schools	0.60	Gravel streets	76	85	89	91
Residential – lots of 10,000 *sq. ft.*	0.50	Residential – 1/8 acre	77	85	90	92
- lots of 12,000 *sq. ft*	0.45	Residential – 1/4 acre	61	75	83	87
- lots of 17,000 *sq. ft*	0.45	Residential – 1/2 acre	54	70	80	85
- lots of 1/2 acre or more	0.40	Residential – 1 acre	51	68	79	84
Parks and unimproved areas	0.34	Newly graded areas	77	86	91	94
Paved and roof areas	0.90	Pasture or grassland	39	61	74	80
Cultivated areas	0.60	Meadow	30	58	71	78
Pasture	0.45	Farmsteads	59	74	82	86
Forest	0.30	Woods- grass combo	32	58	72	79
Steep grass slopes (2:1)	0.70	Woods	30	55	70	77
Shoulder and ditch areas	0.50	Open Space (parks, lawns)	39	61	74	80
Lawns	0.20					

and soils, land use and ground cover can be represented by a single Runoff Curve Number (see Table 1 for examples). The graphical method provides a peak discharge only and is not applicable for situations where a hydrograph is required. The tabular method is a more complete approach and can be used to develop a hydrograph at any point in a watershed.

There are a number of other computer-based storm water hydrologic and water quality models available, such as the U. S. Environmental Protection Agency's Storm Water Management Model (SWMM), which is a comprehensive computer model for analysis of quantity and quality problems associated with urban runoff. Both single event and continuous simulation can be performed on catchments having storm sewers, or combined sewers and natural drainage, for prediction of flows, stages and pollutant concentrations. These models tend to be watershed-scale models, rather than site-scale models.

WHAT'S IN THE RUNOFF?

Sampling Methods and Tools

Sampling of storm water for laboratory analysis and characterization is considerably more difficult than sampling process wastewaters coming out of the end of a pipe, because of the lack of control over sampling times and conditions. Rainfall events often occur at night, on weekends and holidays, and sometimes with little advance notice. It is also difficult to obtain a truly "representative" sample. For example, the storm water discharge permit issued by the Missouri Department of Natural Resources to a private composter requires sampling "during a storm water event of 0.1 inch or greater and during the first 30 minutes of the discharge." This is meant to capture the "first flush" of pollutants swept up by runoff, which is obviously meant to capture a "worst-case" situation. Taking a one-time sample of runoff (known as a "grab" sample) at the wrong time may result in pollutant concentrations that are not truly representative.

Sampling methods to offset this difficulty include flow-composited and time-composited samples, often collected with automated sampling equipment. A flow-proportional composite sample consists of discrete samples collected at a rate proportional to flow. Taking flow-composited samples requires knowing the flow rate of the watercourse, which is normally done by inserting a temporary calibrated V-notch weir in the channel. A time composite sample consists of discrete samples collected at constant time intervals.

Actual procedures used to obtain good quality representative samples are important. Recommended procedures include: wear disposable, powder-free gloves; grab samples with the storm water entering directly into bottles provided by the laboratory (don't transfer them from other containers that may be contaminated with phosphorus-based detergent residue); sample where the water has a moderate flow and some turbulence, if possible, so that the sample is well-mixed; do not overfill the bottle so as not to wash out any sample preservative provided by the laboratory (normally used for ammonia and phosphorus); and cap and label the bottle as soon as the sample is taken (Washington DOE, 2005).

If samples are to be analyzed for biologicals (fecal coliform, other pathogens), the same sample preservation and shipping issues that affect compost samples will affect these water samples. Refrigerate the sample immediately after collection and ship it to the laboratory using an overnight service, packing the sample in iced gelpacks, or the equivalent.

Pollutant Concentrations

Pollutant concentrations in runoff from composting facilities vary widely. A 1997 study by the Clean Washington Center characterized runoff from four composting facilities in the Pacific Northwest, which is shown in Table 2 (CWC, 1997). Another study (Krogmann, 2000) monitored storm water quality for three years at a European composting facility handling residential source-separated organics. The results of that monitoring are shown in Table 3.

The BOD_5/COD_5 ratio is a measure of the biodegradability of a wastewater. A BOD_5/COD_5 ratio of 0.5 is the same order of magnitude as municipal wastewater and is considered easily degradable. A wastewater with a BOD_5/COD_5 ratio less than 0.1 is considered biologically difficult to degrade. The BOD_5/COD_5 ratio of the runoff from the large-scale open windrow facility in Krogmann's study ranged between 0.02 (minimum) and 0.37 (maximum) with a geometric mean of 0.05, suggesting it is a wastestream that may be difficult to biodegrade. ■

Table 2. Runoff ranges from four facilities

Parameter	Range(mg/l)
BOD_5	20 - 3,200
Total solids	1,100 - 19,600
Volatile solids	430 - 9,220
Color (color units)	1,000 - 70,000
Fecal (MPN/100ml)	200 - 24,000,000
Copper (ppb)	33 - 821
Zinc (ppb)	107 - 1,490
Nutrients:	
Ammonia N	32 - 1600
Total Kjeldahl N	14 - 3,000
Nitrate+nitrite N	0 - 8
Total phosphorus	4 - 170
Ortho phosphate	0 - 90
pH (standard units)	6.7 - 9.5
Conductivity	887 - 16,500
Chloride	52 - 2,100
Potassium	167 - 4,640

Table 3. Analysis of runoff from open windrow composting facilities (30 samples)

Parameter	Range(mg/l)
Arsenic (As)	0.001 – 0.044
Lead (Pb)	<0.001 – 0.500
Cadmium (Cd)	<0.001 – 0.172
Zinc (Zn)	0.011 – 2.4
Ammonium (NH_4^+-N)	2.0 – 46.0
Nitrate (NO_3-N)	<0.1 – 96.4
Nitrite (NO_2-N)	<0.1 – 0.80
Chlorides	106 – 445
BOD_5	<2.0 – 513
COD_5	56 – 1768
BOD_5/COD_5 ratio	0.02 – 0.37

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Storm Water Treatment

Segregating storm water flows at composting facilities to minimize generation of highly contaminated runoff goes a long way to reducing treatment costs. Part II

Craig Coker

WATER quality regulations have expanded from individual end-of-pipe point sources to include runoff-generated area nonpoint sources of water pollutants. This has led to increased scrutiny of water pollution potential from rainfall-induced runoff at composting facilities. While all types and configurations of composting facilities are being examined, the majority of attention is on the mainstream technology of open-air turned windrow systems, where rainfall comes into contact with waste materials, composting piles and finished compost products.

Part 1 of this series (February 2008) looked at the quantity and quality considerations of this runoff. The amount and data quality of chemical and biological characterization data for storm water runoff is rather limited; however, available data suggests that compost pile leachate and runoff contaminated with leachate have levels of traditional water pollutants that can exceed levels found in standard domestic wastewater. These pollutants include oxygen-demanding substances, suspended solids, nutrients and bacterial contamination. Other pollutants of importance in compost runoff are heavy metals, oil and grease, and tannins and phenols. Tannins and phenols are derived from the woody materials used in composting, and are derivatives of aromatic hydrocarbons which, if discharged untreated, have potentially significant impacts on aquatic life.

Oxygen-demanding substances in wastewater are normally measured using two surrogates — Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). BOD is normally defined as the amount of oxygen required by bacteria while stabilizing decomposable organic matter in water under aerobic conditions. COD is defined as the total quantity of oxygen needed to completely oxidize all organic matter to carbon dioxide and water. COD values are usually higher than BOD values and may be much greater when significant amounts of biologically resistant organic matter (like lignin in wood fibers) are present. Consuming the dissolved oxygen in waterways has significant adverse effects on aquatic life. Suspended solids washed into streams can blanket and smother bottom-dwelling aquatic life as sediments settle. These solids can also interfere with light transmission and aquatic vegetation photosynthesis if they remain suspended. In addition, they often carry adsorbed oxygen-demanding substances into the water, which cause odor problems as dissolved oxygen levels fall.

Nutrients of importance in water pollution control are the water-soluble forms of nitrogen (ammonia, nitrates and nitrites) as well as phosphorus. These can stimulate the growth of algae in water, which create their own oxygen demands on waters when they die, and ammonia is toxic to aquatic life in sufficient quantities. Contamination of waters with fecal coliform is one of the principal reasons why some waters have lost their "fishable, swimmable" status. Tannins, phenols and similar substances are not only toxic in their own way, but consume dissolved oxygen as they degrade to less complex forms.

Heavy metals such as chromium, copper, lead and zinc are a concern in storm water runoff from urbanized areas, and can be a concern in composting facility runoff, particularly from facilities handling industrial or biosolids feedstocks. As the majority of composting facilities process feedstocks with limited heavy metals, and multi-year sampling at some facilities indicates no migration of heavy metals in compost facility runoff, these are pollutants of largely secondary consideration in developing water pollution control strategies for composting facilities.

REGULATORY APPROACHES

Part 3 of this series (to run in May 2008) will look at how storm water from composting facilities is being regulated. Most states in the U.S. have delegated authority from the U.S. Environmental Protection Agency to regulate point and nonpoint sources of water pollution. Permits issued by state environmental agencies regulate the quantities of pollutants allowed to be discharged. These allowable quantities are converted to concentrations in the discharge (which are easier to measure for compliance) based on allowable quantities of water flow. This approach works well with traditional end-of-pipe discharges from installations where water flow is predictable and relatively consistent.

Water flows in storm water runoff are considerably more unpredictable. There is a varying assortment of control strategies in use by states for controlling potential water pollution from storm water runoff at composting facilities. For example, Oregon has developed a customized storm water per-

mitting program for composting facilities. North Carolina, on the other hand, has decided not to issue any storm water permits for composting facilities, instead making facilities get wastewater discharge permits. Several states use the Multi-Sector General Permit approach used for industrial facilities, choosing to regulate composters under the SIC Code for Fertilizer Mixing (SIC 2875). Others have no regulations at all. It is becoming increasingly clear, however, that composting facilities must plan for control and management of storm water through a combination of both structural and nonstructural management techniques.

REDUCE, REUSE, RECYCLE

Reduce

Reducing the quantities of storm water to be managed is the first step. Under the conditional no exposure exclusion, operators of industrial facilities in any of the categories of "storm water discharges associated with industrial activity," may have the opportunity to certify to a condition of "no exposure" if their industrial materials and operations are not exposed to storm water. At least one in-vessel composting operation in North Carolina is pursuing this to avoid permitting. Several water quality regulators interviewed for this series of articles expressed a desire to see new composting facilities enclosed in buildings, and existing facilities retrofitted with roofed structures to keep rainfall from compost piles.

Another method of reducing the quantity of "contaminated" storm water is through segregation of runoff flows to minimize the quantities of waters with the highest degree of contamination (i.e. leachates). Strategies include site grading to divert up-gradient runoff around a composting facility, using design and construction techniques to segregate leachate from storm water (see "Enzyme Producer Grows Greener With Composting," *BioCycle* December 2006) and isolating vehicle and equipment washing stations with their own runoff containment. By segregating water flows, costs for treating highly-contaminated wastewaters can be reduced and less expensive Best Management Practices (BMPs) and pollution prevention mechanisms can be used for managing lightly contaminated storm waters.

Storm Water Pollution Prevention Plans (SWPPP) are another widely used mechanism to reduce pollutants in storm water. While more specifics are provided in Part 3 of this series, a SWPPP includes: a facility assessment; identification of areas of potential or past pollution discharge; a monitoring (sampling and visual inspection) plan; a schedule for implementing additional or enhanced BMPs; a list of operational and structural BMPs; and development of operation and maintenance procedures (Washington DOE, 2004).

Reuse

The most feasible method of reusing collected storm water is to reintroduce it to the compost piles to keep moisture contents at the optimum 50 to 55 percent level. Windrows can be "irrigated" with hoses, sprinklers or water trucks. As compost piles have considerable water-absorptive capacities, a substantial amount of water can be reused this way. Table 1 shows a sample calculation of how much water can be reused for one irrigation event. Assumptions used in this example include: Facility captures and holds the 25-year, 24-hour storm (6.62 inches for coastal mid-Atlantic state); all up-gradient runoff is diverted around composting facility; capture and contain runoff from 8-acre compost pad; all windrows are covered with fabric and are impermeable; site soils are in Hydrologic Soil Group A or B.

In this example, the windrows are covered with fabric blankets. Open windrows will produce much less runoff to be managed due to absorption of rainwater into the windrow (see Part 1 of this series). While the above method is based on computing the weight of water to be added (and then converting that back to gallons), another formula for calculating the maximum volume of water that can be added to compost piles is (The Composting Association, 2007):

$$V_L = \frac{V_M \times d_M \times (MC_{max} - MC_M)}{100 \times d_L} \times 1000$$

where:

V_L = volume of water to be added (litres)

V_M = total volume of composting material (cubic metres)

d_M = bulk density of composting material (tonnes/cu. meter)

MC_{max}= target moisture content, percent (usually 55%)

MC_M= starting moisture content of pile, percent

d_L= density of water (tonnes/cu. meter)

Because there is some risk that the collected storm water will have fecal coliform contamination, irrigation with storm water should not be done after a compost pile reaches the Process to Further Reduce Pathogens (PFRP) time-temperature standard unless that water has been disinfected. Otherwise, there is a risk of reinoculating a finished compost pile with viable pathogens. This is true even if only yard trimmings or vegetative debris are being composted, as monitoring data has shown elevated levels of fecal coliform in runoff from yard trimmings compost facilities. This fecal contamination is presumably

Table 1. Example storm water reuse calculation

Calculate runoff curve number for site		
Area occupied by windrows =	35 windrows, each 14' wide x 400' long	196,000 SF
Area open		152,480 SF
Total windrow area		348,480 SF
Assumed curve numbers (CN)[1]	Windrows (impervious)	98
	Open areas (packed earth)	85
Weighted average CN =		92.3
Amount of runoff		
Per USDA NRCS rainfall-runoff tables:		
6.62" of rain falling on a CN= 92.3 produces		5.76 inches
Volume of runoff to be controlled		
Runoff amount		5.76 inches
Runoff linear volume (inches x area)		167,270 cubic feet
Runoff liquid volume (1 CF = 7.48 gallons)		1,251,183 gallons
Quantity to be used in windrow irrigation		
Assume 50% of windrows are below PFRP and can be irrigated		
Assume initial moisture content of windrows is 45% and end moisture level is 55%		
Material on pad:	17 windrows x 871 CY/windrow =	14,807 CY
	Convert to weight @ 1200 lbs/CY =	8,884 tons
	Amount of water @ 45% =	3,998 tons
	Amount of water @ 55% =	4,886 tons
	Amount of water to be added =	888 tons
	Volume of water to be added (at 8.4 lbs/gal) =	211,529 gallons
	Amount of water available -	1,251,183 gallons[2]
	Excess irrigation water available =	1,039,654 gallons

[1]Dimensionless numbers that reflect the relative amounts of infiltration versus runoff

[2]Would have to be captured in a pond or tank for reuse

Photos courtesy of Coker Composting & Consulting

The Royal Oak Farm irrigation system consists of 3-inch stanchions around the perimeter of the four compost pads, fed by a network of 6-inch PVC pipes (above). The system serves as both a water reuse function, and for fire fighting purposes (below).

from animal feces mixed in with the yard debris.

Disinfection of collected storm water is possible, using a dosage rate of 5 to 25 mg/L available chlorine (i.e. between 2 and 6.5 ounces of Clorox® bleach per 100 gallons of water). The effectiveness of this depends on the suspended solids content of the storm water, and it may have adverse effects on the composting process once used as irrigation water. In addition, some states may consider this a "wastewater treatment process" for permitting requirements.

Some composters are developing permanent water reuse systems to manage storm water. At Royal Oak Farm, a 500-tons/day open-air turned windrow facility in Evington, Virginia, a subterranean irrigation system was built as part of an upgrade. This system serves both water reuse and fire fighting purposes, and consists of a series of 3-inch stanchions, or standpipes, around the perimeter of the four compost pads, fed by a network of 6-inch PVC pipes. The system is charged by two 30-HP electric pumps, where irrigating windrows is done with one pump in service, drawing water from a lined storm water pond on site. Both pumps are used if fire fighting is needed; additional water can be drawn from a separate farm pond. Royal Oak uses a Backhus windrow turner and a windup hose reel to connect the turner to the irrigation standpipes.

Recycle

One way to recycle composting facility runoff is to use it as irrigation water for crops. These can include row crops, pastureland, turfgrass or biomass silviculture crops (such as hybrid poplar trees). Irrigation methods include overland flow, a spray system, drip irrigation or using subsurface infiltration galleries. Hydraulic loading is a primary design tool when using irrigation to recycle purely storm water. Hydraulic loading, or how much water a field can absorb, is defined by site-specific soil conditions, depths to seasonal high groundwater tables and regional climate considerations (a water balance analysis of precipitation and pan evaporation).

Because composting facility runoff contains nutrients, it is more likely to be regulated as a wastewater and be subject to both nutrient and hydraulic loading constraints. Many states now require land application systems to be based on Nutrient Management Plans (NMPs), which are site- and field-specific assessments of the potential for nitrogen and phosphorus transport to surface waters.

Whether compost facility runoff is classified as a "wastewater" or a "storm water" is a legal question and has implications for recycling via land application. Many states require some degree of treatment of a "wastewater" prior to land application. For example, in Virginia, wastewater to be land applied must be pretreated to a maximum BOD level of 60 mg/L and predisinfected to a maximum fecal coliform level of 200 MPN/100 ml. The degree of disinfection often influences the size of the required buffer zone. In Washington, the setback requirement from property lines is 100 feet if the wastewater meets the disinfection pre-application limit of 200 MPN/100 ml, but climbs to 650 feet if it does not.

TREATMENT STRATEGIES

Traditionally, storm water management has been about managing the quantity of water more than the quality of that water. With the new focus on nonpoint source pollution, the emphasis is now on pollutant removal efficiencies of existing storm water quantity control measures, like detention ponds, as well on treatment devices now on the market, like storm water filtration systems that can be incorporated into a municipal storm drain network.

Best Management Practices

BMPs remain the cornerstone of storm water management strategies, and many are very suitable for use at composting facilities. BMPs are practices, procedures or structural controls used to prevent or reduce adverse impacts to receiving waters. BMPs do this by managing the quantity and quality of the storm water, the leachate from compost piles and equipment washdown wastewater generated at a composting facility. BMPs can be structural, operational or both. Structural BMPs are physical improvements and treatments that can control, treat and protect water quality. Examples include bioretention basins, vegetated filter strips and constructed wetlands. Operational BMPs focus on pollution prevention activities and on operation and maintenance of structural BMPs.

The Oregon Department of Environmental Quality retained the consulting engineering firm, CH2MHill, to evaluate suitable BMPs for composting facilities as part of the background research for development of the new Compost Facility Storm Water Permit program (see Part 3 for more information on this permit). This study ranked 27 BMPs in terms of space efficiency, odor control, cost, level of complexity, number of benchmark constituents potentially controlled and whether the BMP was beneficial for control of bacteria, lead and nitrates (Oregon DEQ, 2004). **Table** 2 lists the 27 BMPs evaluated. The study concluded that these BMPs were suitable for use by composting facilities, with some modifications of definitions to tailor them to composting. Oregon's new compost storm water permitting program requires the use of one or more of these BMPs for runoff that has not been mixed with compost pile leachate. The Fiscal Impact Analysis estimated, for two hypothetical composting operations, total annual BMP costs (amortized capital plus operation) of $87,900 to $114,100. Estimated impact on tipping fees varied from $1.61/ton to $9.10/ton (Oregon DEQ, 2008).

Table 2. BMPs evaluated by Oregon Department of Environmental Quality

Oil water separator
Grading facility areas
Appropriate site vegetation
Graveling or paving
Sediment basins or traps
Bioswale or grassy swale
Soil filter
Wetland
Holding pond/detention basin
Sediment control w/ filter berms
Sediment control w/ centrifugal devices
Granular filtration tanks
Soil and plant systems
Chemical treatment
Coagulation & sedimentation
Aeration & ozonation
Underground injection with pretreatment
Diversion with containment barriers
Liner systems
Collection and reuse
Minimize runoff through operating procedures
Roof structure
Membrane, tarp or cover
Indoor operations
Elimination of standing water
Prompt processing of feedstocks
Shaping of piles

Onsite Treatment

On-site treatment alternatives are complicated by several factors. The degree of treatment needed depends on the ultimate disposition of the contaminated storm water. Another factor is the need for some form of flow equalization, as wastewater treatment systems operate most efficiently under a relatively constant flow. As runoff varies with storm intensity and amount of composting pad occupied by windrows, a retention basin of adequate size is needed upstream of any treatment processes.

If the water is to be reused for crop irrigation via a spray field, then pretreatment (as noted above) is usually sufficient. If it is to be discharged, treatment levels depend on discharge permit levels. In a nutrient-sensitive waterway subject to water quality-based effluent limitations, it is possible that storm water would have to be treated to advanced (or "tertiary") levels. Tertiary effluent discharge concentrations are typically on the order of 3 to 5 mg/L BOD, 3 to 5 mg/L TSS, 1 mg/L Total Nitrogen and 1 mg/L Total Phosphorus.

The pollutants found in composting facility storm water can be treated by several different "unit processes" or in combination "package plants." Table 3 lists some of the various unit processes used in wastewater treatment.

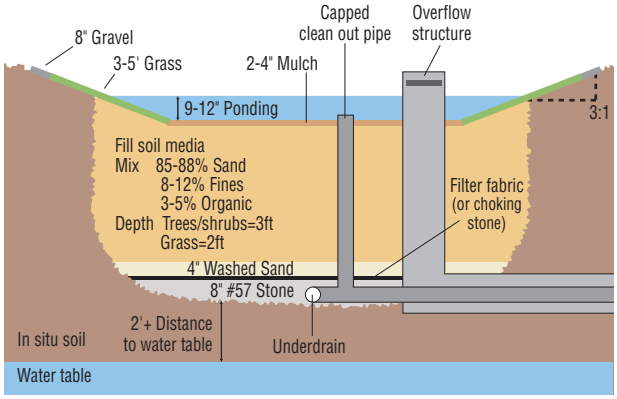
Aeration/oxidation is the process of reducing oxygen-demanding substances by raising dissolved oxygen levels. Most simply, this involves aerating a storm water pond. Numerous types of pond aerators are on the market, but composters should seek models with the highest oxygen transfer rate. For example, in Table 1, a pond could contain 1.25 million gallons after the 24-hour, 25-year storm. If that storm water has a BOD concentration of 100 mg/L, then the pond would contain 1,044 lbs of BOD. One pond aerator on the market has an oxygen transfer rate of 6.8 lbs/hour, so that aerator would have to run 153.5 hours to consume the entire BOD in the pond (neglecting microbial uptake and utilization of both oxygen-demanding organic materials and the dissolved oxygen in the water).

Table 3. Water pollutants and treatment processes

Water Pollutant	*Treatment Process*
BOD/COD	Aeration/oxidation Biological conversion
Suspended solids	Clarification Filtration
Fecal coliform	Disinfection (Chlorine, Ozone, UV) Biological conversion
Nitrogen and phosphorus	Biological conversion Precipitation (phosphorus only)
Heavy metals	Precipitation Adsorption

Biological conversion is the fundamental process used in activated sludge and fixed-film wastewater treatment systems (i.e. aerobic lagoons), as well as the processes at work in biologically-rich features like engineered wetlands, bioretention basins, bioswales, etc. Biological conversion will reduce pollutant concentrations of BOD, fecal coliform, some heavy metals and nutrients. Bioretention ponds (also known as rain gardens) are becoming widespread in areas adopting Low Impact Development policies, and have been shown to remove significant amounts of pollutants from storm water. Figure 1 illustrates a conceptual cross section of a bioretention pond.

Figure 1. Bioretention pond cross section



Suspended solids are a common problem in compost storm water systems due to compost fines washed in with the runoff. Keeping solids out of storm water management systems provides several benefits: improves the efficiency of other treatment processes, such as disinfection; eliminates or reduces difficult maintenance tasks in lined ponds; reduces or eliminates the potential for anaerobic conditions to form in a pond or basin (with accompanying malodors); and minimizes the potential for discharge of solids in the event of a pond overflow. Use of Filtrexx™ compost-filled filter socks is an inexpensive way to keep solids out of ponds.

Disinfecting storm water for either reuse in the compost pile, for recycling via a spray field or for discharge permit compliance is difficult. The three primary methods are adding chlorine-containing compounds (like sodium hypochlorite), making and introducing ozone gas into the water or passing the water through a bank of ultraviolet lights for irradiation. All three methods are sensitive to the suspended solids levels in the storm water. A new process for disinfecting storm water is electrocoagulation, which was originally used for precipitating heavy metals out of wastewater. A 2004 pilot study on urban runoff in Los Angeles showed a 99 percent removal of total coliform, a 98 percent removal of chromium, a 96 percent removal of copper and a 98 percent removal of lead (Brzozowski, 2007).

Engineered wetlands may offer one of the best alternatives for management of composting facility runoff. Wetlands have a higher rate of biological activity than most ecosystems and, as a result, are capable of transforming the conventional pollutants found in storm water into harmless byproducts, or into nutrients that can be used to encourage higher levels of biological productivity (see sidebar).

Pump & Haul

In some cases, composting facilities may have to consider "pump-and-haul." Due to capacity restrictions at the local treatment plant, and to extremely strict water quality standards in the watershed of a potable water reservoir, this is an alternative being considered for the Durham, North Carolina Yard Waste Composting Facility. North Carolina regulations require the capture and management of the runoff from the 24-hour, 25-year storm, which in the case of Durham, is about 1.8 million gallons. At $0.15/gallon cost to pump, haul and discharge at a treatment plant, this could be a cost of $270,000 each time the pond has to be emptied.

BOTTOM LINE

Water quality management — along with odor control and air emissions —may well be another powerful impetus for new composting facilities to consider in-vessel systems or enclosure in buildings. New open-air facilities likely will need to carefully engineer sites to segregate storm water runoff into manageable amounts to limit the quantity of highly contaminated and associated high-cost treatment requirements. Existing facilities facing permit renewals in states with aggressive storm water management programs likely will have to consider multiple management measures, including pollution prevention operational practices, and combinations of water quantity and water quality management facilities. ■

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April, 2008
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POLLUTANT REMOVAL VIA WETLANDS

THERE are two main types of engineered, or constructed, wetlands — the Free-Water-Surface (FWS) wetland, which has a standing pool of water, and a Subsurface-Flow (SF) wetland, in which water lies below the surface of the wetlands media (usually gravel). FWS wetlands don't work well in northern cold regions, but SF wetlands have been shown to operate satisfactorily at subzero temperatures in Wyoming and Montana. Wetlands have measured pollutant removal efficiencies of 24 to 70 percent for phosphorus and between 31 and 84 percent for nitrogen.

Research underway at Virginia Tech (Virginia Polytechnic Institute and State University) suggests that combining engineered wetlands with conventional retention ponds can increase phosphorus removal above those levels. SF wetlands are being used to treat dairy feedlot runoff (high BOD and nutrients) in Vermont and are being used to treat airport deicing facility runoff in Buffalo, New York and Hartford, Connecticut. With the Buffalo project, the runoff has a BOD load in excess of 10,000 lbs/day and an effluent discharge permit level of 30 mg/L (Whitney, 2008).

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(Editor's note: there are literally hundreds of companies providing water treatment technologies; this partial list is only provided as a courtesy to BioCycle readers, and should not be interpreted to be either complete or an endorsement of any of these companies or their products)

WATER QUALITY

STORM WATER MANAGEMENT REGULATIONS

Regulations and permits for storm water at composting facilities involve many site-specific criteria.

Part III

Craig Coker

THE Clean Water Act of 1972 created the National Pollutant Discharge Elimination System (NPDES). Under NPDES, all facilities that discharge pollutants from any point source into U.S. waters are required to obtain a permit. The U.S. Environmental Protection Agency (EPA), which enforces the Clean Water Act (CWA), developed three types of NPDES permits for discharges comprised solely of storm water: individual, general and group (or "multisector") general permits. Most states are delegated authority from EPA to regulate storm water discharges with these types of permits.

Individual storm water permits are very similar to standard NPDES permits, setting specific numerical effluent limitations on conventional, nonconventional and toxic pollutants, and on hazardous substances. General permits are largely used to control storm water discharges from construction sites disturbing one or more acres of land (some industrial activities fall under these baseline general permits). Multi-sector general permits (MSGP) are aimed at controlling storm water discharges from similar types of industrial activities, and are grouped along the lines of Standard Industrial Classification (SIC) Codes, in the belief that most industrial activities within a particular SIC Code were fundamentally similar with regard to potential storm water runoff contamination potentials.

The challenge for the composting industry is that its facilities do not fall neatly under one of the regulated industrial categories. None of the specified SIC codes apply specifically to composting facilities, although some composting facilities do use an SIC Code requiring coverage (SIC 2875 – Fertilizers, Mixing Only). Others that have been used include SIC 4953 (Landfills) for facilities that are located at landfills, and SIC 2499 (Wood Processing, Misc.). In addition, those composting facilities located on farms are exempt from the storm water permitting requirements of the CWA, yet some of those facilities rival the more "industrial-scale" facilities found elsewhere in size, scale and potential water quality impact.

Storm water discharge general permits issued to multi-sector SIC code industries (like composters in the SIC 2875 category), while called NPDES permits, do not have the same effluent limitations on pollutant concentration, pollutant loading and flow that is found in traditional end-of-pipe NPDES permits for point sources. These general permits are based on periodic monitoring of key pollutants (correlated with the typical storm water contamination profile of that particular SIC Code) and the preparation and implementation of pollution prevention programs.

The monitoring parameters are called "benchmarks," and the permitted party is expected to monitor storm water runoff (during a rain event) for those parameters on a periodic basis, either quarterly, semi-annually or annually. If it's detected that benchmarks have been exceeded, the permitted party is expected to intensify their storm water pollution prevention activities. A Storm Water Pollution Prevention Plan (usually designated as a SWP3 Plan) consists of mapping showing locations of pollution sources, receiving streams and Best Management Practices (BMPs).

Operational BMPs are basic, everyday practices and relatively small structural or equipment requirements that can be effective in preventing pollution, reducing potential pollutants at the source. Operational practices would include housekeeping details like sweeping compost pads with a rotary broom and policies to require periodic inspections of storm water management facilities (i.e. looking for trash blockages of drains, etc.). Structural BMPs are measures that control or manage storm water runoff and drainage. Examples include covers and enclosures used to isolate composting and curing pads, and product storage areas from rainfall; swales, dikes and berms to divert up-gradient runoff from the facility; and storm water detention basins, vegetative filter strips, rain gardens (or bioretention ponds) and constructed wetlands to manage collected runoff.

Part I (February 2008) of this series on storm water management at composting facilities discussed methods for quantifying storm water runoff and some of the constituents in the runoff that are of concern in water pollution control. Part II (April 2008) focused on storm water treatment options. Part III reviews regulations in seven states.

STATE REGULATORY STRATEGIES

States vary widely with regard to how storm water from composting facilities is

regulated. Regulators from several states were contacted for information about how compost facility storm water was regulated:

Kansas: Ken Powell, an Environmental Scientist with the Kansas Department of Health notes, "Compost facilities are split into five categories in our regulations: yard waste, manure, livestock (which means dead animals), source-separated organic waste and municipal solid waste. Leachate and storm water controls are required at all composting facilities. All of the facilities in Kansas are currently windrow facilities. Any leachate would mix with the storm water. With the exception of MSW composting, all of our facilities use either a grass filter strip alone or in combination with a storm water retention structure. Excess water in the control structures can be used for watering the windrows or irrigated on crop fields. We do not currently have any MSW composting facilities, but they would be required to be connected to a municipal sewer system or to haul the leachate to a municipal sewer system. MSW facilities are also required to be covered, so they should generate very little leachate. In Kansas we have not required NPDES permits since no unfiltered runoff should leave the facility.

Missouri: Missouri uses the SIC 2875 industrial MSGP to regulate storm water from composting facilities. Missouri uses two different categories of composting facilities under this SIC Code, one for operations of less than 20 acres composed of feedstocks from agricultural, wood and food product sources (Permit No. MO-G090000); and the other for operations under 20 acres handling any sort of feedstock (Permit No. MO-G920000). Facilities permitted under this SIC Code category must be nondischarging, except in the event of "emergency discharges during catastrophic rain events." This is defined as the 1 in 25 year, 24-hour rainfall, which ranges from 5.6 to 7 inches of rain in Missouri. Permits issued under the MO-G920000 category require composters to test feedstocks for heavy metals (not just compost). Benchmark monitoring requirements include BOD, TSS, oil and grease, fecal coliform, pH, temperature, ammonia-nitrogen, other forms of nitrogen and phosphorus. Land application of the retained storm water is limited to rates of less than 650,000 gallons per acre per year. These general permits are tailored to a particular facility's operation.

North Carolina: Recent regulatory decisions in North Carolina have caused considerable concern for composters, as the state's Department of Environment and Natural Resources (DENR) has decided to deny any future requests for storm water discharge permits from composting facilities. "Over the past year, we have seen an increasing number of composting operations seeking NPDES storm water discharge permits," said Bradley Bennett, Stormwater Permitting Unit Supervisor at North Carolina DENR. "Based on the analytical data we've seen, pollutant levels in storm water are more characteristic of wastewater. It is also now clear that leachate from composting operations is a wastewater and poses water quality concerns without adequate treatment. We are also concerned about leachate from finished compost storage piles. Leachate and runoff from these piles can still introduce concentrated amounts of oxygen demand, nutrients, solids and other pollutants into surface waters. We have decided, unlike other states, that runoff from finished compost piles is not storm water, it is a leachate, and should be regulated as a wastewater."

Oregon DEQ developed a specific permit for composters focused on the use of BMPs to treat storm water.

North Carolina DENR's wastewater rule requires that all nondischarge alternatives be fully explored before a wastewater discharge permit is issued. Alternatives include: eliminate exposure to rain by enclosing the facility; internal recycling as irrigation water for compost process control; spray application on land; diversion to a wastewater treatment plant (WWTP) through the sanitary sewer system; diversion to a WWTP through a "pump-and-haul;" or treatment on-site through a permitted treatment system (i.e. a "package" WWTP, a constructed wetlands, an evapotranspiration drainfield, etc., or some combination of technologies). Only after demonstrating that none of the preceding is feasible, will DENR entertain an application for a discharge. Discharges will be subject to water-quality based effluent limits as needed (i.e., Total Maximum Daily Loads, whole effluent toxicity, etc.), and would have effluent limitations much like a regular point-source municipal or industrial wastewater discharge.

"Since the policy went into effect, Wallace Farms (a multi-feedstock industrial composter) has decided to divert to the sanitary sewer system, Brooks (a multi-feedstock industrial composter) is working on a plan for an on-site treatment system, the City of Durham (a yard waste composter) is considering a pump-and-haul to a WWTP and Warren Wilson College (an institutional in-vessel composter) is considering an exclusion from coverage based on being in-vessel," said Frank Franciosi of the Carolinas Composting Council. Discussions are underway between the Council and DENR about the nature and types of cost-effective on-site treatment systems that will meet state water quality permitting requirements.

Oregon: One of the more progressive approaches to managing storm water may be found in Oregon. "We found that regulating storm water from composting facilities under the Industrial General Storm Water Permits didn't adequately cover all on-site activities of composters," says Jenine Camilleri, with the Water Quality Divi-

sion of Oregon Department of Environmental Quality (DEQ). "So we developed a specific storm water permit for composters, known as the 1200-CP General Storm Water Permit." This new permit is focused on the use of BMPs to treat storm water from compost. Quarterly monitoring will be required of BOD and phosphorus in addition to the standard industrial storm water monitoring parameters of copper, lead, zinc, pH, suspended solids and oil and grease. This permit also requires: public notice and comment on the application and on the storm water management plan; requires runoff meet in-stream water quality standards; and composting facilities obtain an individual NPDES permit if they have failed after the fourth year of permit coverage to consistently meet the monitoring benchmarks. (Table 1 lists proposed benchmarks). Exemptions from this rule will be limited to home composting, agricultural composting of agricultural waste and institutional composting of self-generated wastes (and on-site use of the resulting compost only).

Under new composting rules being prepared by Oregon DEQ Land Quality (which include the new storm water permit rules), leachate will have to be segregated from storm water and handled separately. If leachate is commingled with storm water, the facility is not eligible for the 1200-CP permit. "We're considering a joint permitting process for both permits (Solid Waste and Water Quality) with one application," notes Camilleri. The new rules (currently in draft form) will require that leachate production be minimized, that it be collected and directed to an impermeable containment structure, that tanks used to store leachate have secondary containment and that it be either directed to a treatment plant, or if treated on-site, then discharged under a NPDES permit with effluent limitations.

Virginia: Solid waste composting facilities (which includes everything from yard trimmings to commingled municipal solid waste) are required to capture, contain and prevent discharge of runoff from the 1-hour, 10-year storm. Runoff above that level is regulated under the Industrial Activity General Permit for SIC 2875 (Fertilizers, mixing only). Benchmark monitoring parameters are: Total Nitrogen (2.2 mg/l), Total Recoverable Iron (1.0 mg/l), Total Recoverable Zinc (120 µg/l) and Total Phosphorus (2 mg/l). Facilities are also required to conduct visual monitoring (recording their observations), annual monitoring and preparation and adoption of a SWP3 Plan.

Washington: Composting facilities in Washington are required to separate leachate from storm water; storm water running off a compost pad is considered leachate. "Compost facilities here usually require an Industrial Storm Water NPDES permit," said Chery Sullivan, a composting specialist with the Washington Department of Ecology. "Washington has been delegated to run EPA's NPDES permit program and is authorized to administer the Industrial Storm Water NPDES in lieu of EPA's Multi-Sector permit." She also noted that most facilities manage storm water onsite through detention and infiltration or discharge storm water offsite under a permit. "If they manage storm water onsite, they may not need a permit," Sullivan said. "Depth to groundwater, runoff volume and risk of contamination all play a role in the determination of needing a permit for those who retain storm water on site."

Table 1. Oregon's proposed storm water monitoring benchmarks for composting operations

Parameter	*Benchmark*
Total copper	0.1 mg/l
Total lead	0.4 mg/l
Total zinc	0.6 mg/l
pH	5.5 – 9.0 SU
Total suspended solids	130 mg/l
Total oil & grease	10 mg/l
BOD_5	30 mg/l
Total phosphorous	2 mg/l
Floating solids (associated with composting activities)	No visible discharge
Oil & grease sheen	No visible sheen

[1]Applies only to facilities not discharging to the Columbia Slough Watershed; those facilities also have an *E. Coli* monitoring benchmark and different benchmark concentrations than those above.

Wisconsin: In Wisconsin, leachate is regulated and is required to be segregated from storm water. "Leachate treatment is required to a varying extent depending on the facility," said Gretchen Wheat, an engineer with the Wisconsin Department of Natural Resources (WIDNR). "It depends on waste types, facility size, location factors, etc. Berms, ditches or other means must be used to prevent run-on of noncontact storm water. Leachate includes water that comes in contact with materials in the composting process."

Brad Wolbert, a hydrogeologist with WIDNR's, Bureau of Waste and Materials Management, has recently taken the lead on solid waste composting. Wolbert explained, "Solid waste composting facilities with feedstocks limited to certain source segregated materials are regulated by s. NR 502.12. The rule is mainly for yard materials and vegetable food waste composted by low tech methods. Composting facilities that are small or have lower nutrient materials can generally discharge leachate or run off to a vegetated filter strip area. Facilities that are large or have higher nutrients need to capture leachate, and the rule specifies two management options: recirculate into the composting process, or discharge to permitted wastewater treatment facility. Potentially leachate could be discharged to a wastewater treatment strip, but a WPDES Permit may be required, and

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May, 2008
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an applicant would need to demonstrate the effectiveness of any proposed treatment option. Composting of other feedstocks is regulated by s. NR 502.08, Wisconsin Administrative Code, a more generally written rule that allows flexibility to address processing of various solid wastes by any method shown to be environmentally sound."

Wolbert went on to note, "Storm water from a compost pad is considered leachate, and a curing pad is considered a compost pad. So, runoff from curing pads is regulated under the same authority, but different (less) treatment might be needed. Product storage piles may also be regulated under the same authority, but again, required treatment would be less."

Wheat added, "A starting place to guide compost leachate treatment design might be Natural Resource Conservation Service (NRCS) Standards 635 Wastewater Treatment Strip, 393 Filter Strip and 590 Nutrient Management. Treatment strip design commonly includes capture of more concentrated initial flow. However, manure has much higher nutrients than expected in compost leachate, so I'm not suggesting to directly use NRCS Standards." ■

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