ENVIRONMENTAL IMPACT OF YARD WASTE COMPOSTING

Monitoring program examines soil for changes in heavy metal content, samples water infiltrating beneath site, and tests finished compost for nutrients, heavy metals and pesticide residues.

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YARD WASTE COMPOSTING facilities are proliferating across the nation, in large part due to the rapidly escalating cost of traditional disposal options. Composting yard waste in outdoor windrows is certainly less expensive than state of the art landfills or waste-to-energy facilities, with compost processing costs in Westchester County ranging from four to 22 dollars a ton (Sherman, 1989). But most promoters of composting assume that composting is also environmentally benign, often without any hard evidence to back that up. In the absence of data, government regulators have proposed a wide range of constraints, including well and water setback distances, management restrictions, and in some cases even impermeable liners under the site. The goal of this study is to provide some of that missing information, so that composting facilities can operate in a way which is environmentally sound and economically efficient.

The study was designed to evaluate the impact of municipal leaf composting on soil, water, and the compost quality itself. The environmental monitoring examined soil samples for changes in heavy metal content, sampled water infiltrating beneath the site for common water pollution indicators, and tested the finished compost product for nutrients, heavy metals, and pesticide residues.

SITE DESCRIPTION AND OPERATIONS

The Croton Point, New York composting facility is located adjacent to a closed county landfill on county owned land bordered by a public park and a private industrial facility. Leaves used for the study were from the village of Croton-on-Hudson, a community of 7,300 people about 20 miles north of New York City. Leaves were collected at the curb with vacuum collector trucks, with each truckload weighed as it was brought to the site.

Five hundred tons of leaves (4,800 cubic yards) were brought to the site between mid October and late December of 1988. Leaves were immediately stacked in windrows approximately 8 feet tall and 12 feet wide. Water was added to the windrows at a rate of approximately four gallons per cubic yard. Most of this water was injected into the interior of the windrows using a pipe attached to a hose from a water truck.

All the windrows were turned using a front-end loader on a bi-weekly basis, combining windrows as necessary after the initial volume reduction to maintain a minimum 6 feet height and 12 feet width through the winter. Temperatures in the interior of the windrows ranged from 100°F to 140°F through February, and then slowly dropped toward ambient temperature. One windrow received additional turnings, once with a Scarab, once with a Wildcat, and weekly with a front-end loader between March and June. While the shredding action provided by both of the specialized windrow turning units had a significant effect on compost quality and process speed, the additional turnings with the front-end loader did not appear to accelerate the process.

By mid-June 1989, the original 4800 cubic yards had been reduced in volume by 70 percent, to about 1400 cubic yards. All the compost at the site was judged to be of a marketable quality by July. During August and September most of the finished compost was mixed with sand and used by the county in various public works projects. The balance of the compost was offered and given to residents of Westchester County on one weekend in October, 1989.

ATER QUALITY MONITORING

Water quality protection is one of the pri- ary aims of current regulatory restrictions n compost facility siting. The New York tate Department of Environmental Conser- ation (DEC) currently requires a yard waste ɔmpost facility to be located at least 200 et from wells or surface water, and 25 feet om a drainage swale. These distances are rbitrary, in that they are independent of soil ıd vegetation as well as compost runoff haracteristics. This study begins to provide ıe base of information needed to develop ra- onal environmental protection strategies.

The emphasis of this experiment was on ıonitoring the water infiltrating beneath the ɔmpost site, in order to gauge its probable fect on local groundwater quality. Because he site was located between a closed landfill nd an industrial facility, the source of any ontamination detected in the underlying roundwater would be difficult, if not impos- ıble to ascertain. Our strategy was to sam- le clean soil immediately beneath the com- ost windrows, using suction lysimeters that re able to extract water samples from the nsaturated zone. To assure a clean soil ma- rix for sampling, as well as provide a suit- ble composting pad, an 18- to 24-inch thick ayer of clean sandy soil was spread over the ntire site and graded to a one percent slope.

Suction lysimeters were laid out in two ransects perpendicular to the windrows, vith samplers spaced at two meter intervals ı each transect (see Figure 1). A cluster of pgradient samplers was located in addi- ional clean soil adjacent to the site. The po- ous ceramic cup suction lysimeters were laced 12 inches to 18 inches under the sur- ace. Sampling the unsaturated zone this ear the surface is extremely moisture de- endant, and during low moisture periods amples proved difficult to extract. To pro- ect the sampling equipment from damage lue to heavy equipment, vacuum and sam- ling tubes from each transect of lysimeters vere laid in a common trench to a sampling oint adjacent to the composting pad.

Samples were collected on October 18, .988, and May 3, 1989. Low moisture condi- ions prevented sample collection during at- empts on December 12 and March 15. Each vater sample was split and sent to two labo- atories. Phenol, Chemical Oxygen Demand (COD) and Biological Oxygen Demand BOD) analysis was carried out by Buck En- gineering Laboratory in Cortland, NY. The Cornell University Agronomy Laboratory completed the remainder of the analysis for ııtrate, nitrite, total nitrogen, total phospho- ous, and metals. Color and pH testing were performed by project staff.

Samples drawn from twelve lysimeters on October 18 (prior to leaf delivery) established the background conditions for the site. The majority of the results were well within the boundaries considered "normal." A few out- ying data points included iron (3.3 milli- grams per liter (mg/l)), chromium (2.2 mg/l), and nitrogen (12.6 and 28.3 mg/l). These might be related to metal or organic objects in the fill directly beneath the site, but could also be the result of sampling or laboratory error, since these high values were not found again in later samples from the same loca- tions. No phenolic compounds were detected in any of the samples collected. These back- ground results indicate some variation due to the composition of the soil and the mate- rial underlying the site, but nothing that would considerably interfere with interpret- ing later results.

A dry winter delayed additional sample collection until May 2 and 3, 1989. Heavy rain at that time permitted a complete sam- pling of the infiltration from sixteen lysime- ters under the compost site. Table 1 com- pares these results with the background water concentration as well as New York State's groundwater discharge standards. Of the groundwater heavy metal standards, only the iron (Fe) standard was threatened, with an average value of 0.57 (mg/L) com- pared with the 0.60 mg/L standard. It is worth noting that even that value was lower than the average background iron concentra- tion for the site. The relatively low concen- tration of metals infiltrating from this site is a reflection of the low metal content of the leaf compost, as described in a later section.

While the metal concentrations do not in- dicate a significant contribution from the leaf compost, some of the organic constitu- ents were considerably elevated. Phenols, for example, went from background levels con- sistently below the limits of detection of 0.18 mg/L, well above the groundwater discharge standard of 0.002 mg/L. Phenols are a natu- ral product of decomposing lignin, and thus would be expected at a leaf composting site, much as they are found in swamps and other areas where large amounts of organic matter decompose. These natural phenols can com- promise the taste and odor of drinking water but are non-toxic, and it is important to dis- tinguish them from industrial phenols, sev- eral of which are extremely toxic in low con- centrations. Thus, this extremely low groundwater discharge standard, which is designed to protect water supplies from toxic industrial phenols, may not be relevant to the natural phenols generated by the com- posting process.

Biochemical Oxygen Demand (BOD) is the other parameter which was found in concen- trations above the normally acceptable dis- charge levels. Three of the BOD samples were above the measurement range of 150 mg/L, and the average of the sixteen samples exceeded the surface water discharge stan- dard of 30 mg/L. High concentrations of BOD in runoff can deplete the dissolved oxy- gen in lakes or streams, which can have a negative impact on aquatic life.

Both phenols and BOD are parameters that can be substantially reduced by soil deg- radation processes (Martin and Focht, 1977; Loehr et. al., 1979), and these levels would not be expected to contaminate groundwater supplies. However, they could become a threat if released in significant quantities di- rectly to lakes or streams.

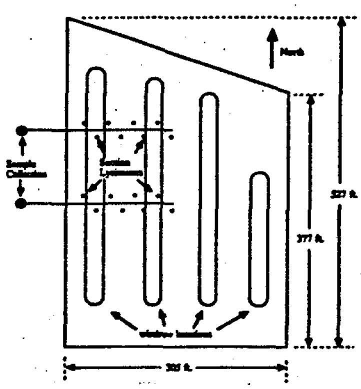

Figure 1: Croton Point Compost Site. Windrow location and suction lysimeter layout.

Table 1. Croton Point Compost Site Water Quality Data

	Background Data (12 samples)		Compost Infiltration Data (16 samples)		DEC Standard †
	Average (mg/L)	Std. Deviation (mg/L)	Average (mg/L)	Std. Deviation (mg/L)	(mg/L)
Cd	ND		ND		0.02
Cu	0.01	0.01	ND		1.00
Ni	0.15	0.21	ND		2.00
Cr	0.45	0.71	ND		0.10
Zn	0.05	0.05	0.11	0.13	5.00
Al	0.22	0.13	0.33	0.38	2.00
Fe	1.75	2.29	0.57	0.78	0.60
Pb	0.05	0.06	0.01	0.02	0.05
K	0.79	0.54	2.70	0.99	•
NH4-N	0.11	0.11	0.44	0.35	•
NO3-N	2.10	9.72	0.96	1.00	20.00
NO2-N	ND		0.02	0.02	•
Phosphorus	0.02	0.02	0.07	0.08	•
Phenols (total)	ND		0.18	0.45	0.002
COD	17.90	15.39	256.33	371.22	•
BOD	3.26	1.57	>41††	>60	30.00**
pH	7.80	0.43	7.75	0.36	6.5-8.5
color	ND		ND		not detrimental
odor	ND		ND		not detrimental

† *From 6NYCRR Chapter X Division of Water Resources S 703.6 Effluent standards and/or limitations for discharges to class GA (groundwater) in New York State.*
• *No water quality standard in New York State*
†† *Includes 3 samples above detection limit of 150 mg/L*
** *Standard discharge limit for treated wastewater effluent*
ND Not Detected

Table 2. Soils Data - Croton Point Compost Site

	Units	Background Data (2-10 samples)		Post Operations Data (12 samples)		Natural
		Average	Std. Deviation	Average	Std. Deviation	Average
Metals						
Cd	(ppm)	ND		ND		0.1†
Pb	(ppm)	34.65	7.71	ND		10†
Cu	(ppm)	12.12	0.41	12.94	4.13	30†
Ni	(ppm)	21.21	0.66	11.15	2.35	40†
Cr	(ppm)	50.39	3.65	54.74	12.77	100†
Co	(ppm)	17.62	1.43	8.19	1.66	8†
Zn	(ppm)	60.03	8.78	32.91	5.21	50†
Mn	(ppm)	737.20	34.37	432.50	81.33	600†
B	(ppm)	46.96	2.85	14.31	2.48	NA
Fe	(%)	3.52	0.18	1.98	0.37	2.5*
Al	(%)	5.42	0.00	6.26	1.33	NA
Ti	(%)	0.36	0.03	0.24	0.04	NA
Na	(%)	1.15	0.08	2.22	0.02	0.1*
Nutrients						
NO3-N	(ppm)	2.25	0.07	5.03	1.93	varies
P	(%)	0.09	0.01	0.03	0.01	0.1*
K	(%)	1.36	0.11	1.44	0.05	1.9*
Ca	(%)	2.08	0.36	1.45	0.27	0.9*
Mg	(%)	1.24	0.25	0.63	0.15	0.7*
S	(%)	ND		ND		NA
pH		6.90	0.20	7.67	0.25	varies

ND Not Detected
NA Not Available
† *From USEPA Office of Solid Waste and Emergency Response, Hazardous Waste Land Treatment. SW-874 (April, 1983) pp. 273, Table 6.46.*
• *Average for twenty soils in New York State (L.M. Naylor, personal communication)*

Nitrate (NO_3) levels, which are freque viewed as a major pollution threat from ganic wastes, remained well below the s dard of 20 mg/L throughout the study, even below the background values for site. These extremely low nitrate concen tions may be attributed to the fact that composting is a nitrogen limited proc and nitrogen rich composting such as wo occur with grass clippings or supplement nitrogen would be expected to generate c siderably higher nitrate levels.

SOIL ANALYSIS

Soil testing was undertaken to ascert whether any significant changes in soil ch acteristics would result from composting tivities. Background testing of the soil Croton was carried out in October 1988, pr to leaf arrival at the site. Major nutrient a pH analysis was completed for ten sampl and metals were analyzed for two samples. second set of twelve samples was collected June 1989, and all those samples were an lyzed for metals, nutrients, and pH. All an yses were completed by the Cornell Unive sity Agronomy Laboratory. The resul showed few values even approaching the le els considered average for natural soils (se Table 2).

Sodium was the only element whose con centration in the soil was significantly highe than typical soil averages, but this value wa high in the background samples as well as in the "post operations" samples taken afte seven months of composting. These some what elevated sodium levels may be relate to the site's proximity to salt water, and are still far below the levels that might cause harm to plants. Some concern has been raised about the effect of road salt on street leaves collected in early winter. To examine this question, separate samples of both soil and finished compost were collected from the part of the site that received leaves after road salt had been applied in Croton. In both cases there was no significant difference in sodium levels in this area compared with other areas of the compost site. If additional salt was brought to the site with these leaves, it apparently leached out of the compost and soil by the following summer.

COMPOST PRODUCT QUALITY

The finished compost produced by this project was analyzed for both its fertilizer value as well as any potential contamination that might limit the product's use. A set of five samples was tested for nutrients and metals, and twelve samples were tested for pesticide residues. The results of this analysis are presented in Table 3.

The Cornell University Agronomy Laboratory conducted all nutrient and metal analysis. Nutrient levels found were all in the normal range for leaf compost, and indicate that this material should prove a high quality soil amendment for many gardening and landscape uses. The one constraint posed by this compost is its somewhat elevated pH, which is a measure of the soil's acidity or alkalinity.

At pH 8.2 (neutral is 7), this compost is more alkaline than many other soil amendments, and would not be recommended for acid loving plants without the addition of sulfur or another acidifying agent. However, this leaf compost would be highly suitable for application to lawns, most trees, and other general gardening uses. And for those gardeners or landscapers who are faced with an overly acidic soil, this compost could be an aid in neutralizing that acidity.

Metal analysis is becoming a fairly standard procedure for many waste materials, particularly those which are destined to be used in agricultural or horticultural settings. Of particular concern is the potential presence of lead, cadmium and other toxic metals that tend to accumulate on leaves and on streets in urban areas. Table 3 shows that the heavy metal concentration found in the Croton Point leaf compost is considerably lower than the concentrations allowed by the Class 1 compost criteria for the DEC. Class 1 compost is the highest grade of compost, and can be distributed to the public for widespread use on horticultural and agricultural crops. In fact, comparing this data to Table 2, the heavy metal concentrations in the compost are very similar to the background concentrations in soil. Thus, the heavy metal content of this leaf compost does not pose a threat to local health, soil or water quality.

Pesticide residue analysis was conducted by the Agway Technical Center's Analytical Services Division in Ithaca, NY. The analytical procedure used the methods developed by the U.S. Food and Drug Administration (USDA) to screen pesticide residues in food, which covers over 200 pesticides. Only four pesticides were detected: captan, chlordane, lindane, and 2,4-D. Of these, all except chlordane were found in concentrations well below the USDA food tolerance level. The food tolerance level provides a conservative indicator of the compost's safety for use in home gardens, since any residue found in compost would be further degraded and diluted before being absorbed by plants.

Chlordane was banned for use in the United States in 1988, and between 1983 and 1988 was used almost exclusively for termite control. Prior to 1983 chlordane was approved for home lawn and garden use as well as on agricultural crops. Chlordane is strongly adsorbed to the organic fraction of soil, and probably was introduced to the leaves during raking on lawns and around house foundations.

The concentration of chlordane-related compounds (CRCs) found in the leaf compost was 0.09 parts per million (ppm), which, although it is above the USDA food tolerance level of 0.03 ppm, is still well within the range of typical background levels for suburban soils. For comparison, a study by the DEC of pesticide residues on golf courses throughout New York State found total CRCs on fairways averaged 0.72 ppm, while on greens the average was 11.14 ppm (Okoniewski, 1989). Some suburban lawns were also sampled in the DEC study, where CRC concentrations ranged from 0.06 ppm to 15.0 ppm. The Croton Point leaf compost is clearly at the low range of these values.

The CRCs detected in the leaf compost samples included several different byproducts of chlordane degradation, including cischlordane, trans chlordane, chlordene epoxide, heptachlor, octachlor epoxide, and trans-nonachlor. The presence of so many degradation by-products is an indication that the chlordane is breaking down. With the banning of chlordane, residues in lawns and soil can be expected to decrease even more in the future. Since the CRC levels are already low relative to background levels in suburban soils, and are tightly bound to the compost itself, these residues should not constrain the use of the compost.

SUMMARY AND IMPLICATIONS

This study demonstrates that municipal leaf composting can be practiced in an environmentally benign manner. However, there are a few aspects of this process that can potentially create problems. For leaf composting, the primary concerns are BOD and phenol concentrations found in water runoff and percolation. These concerns can and should be mitigated through proper facility design and management.

The Westchester County leaf composting demonstration site at Croton Point. Photo by Nancy Dickson.

Table 3. Compost Quality Data - Croton Point Compost Site

	Finished Compost (June 1989) Units	Average	Std. Deviation	Standards
Nutrients				
N	(%)	0.62	0.19	NS
P	(%)	0.04	0.01	NS
K	(%)	1.11	0.10	NS
Ca	(%)	1.84	0.11	NS
Mg	(%)	0.59	0.03	NS
S	(%)	0.23	0.03	NS
Organic Matter	(%)	22.44	6.87	NS
Water Content	(%)	54.60	6.90	NS
pH		8.16	0.21	NS
Metals				
Cd	(ppm)	ND	ND	10†
Ni	(ppm)	10.08	0.91	200†
Pb	(ppm)	31.70	9.57	250†
Cu	(ppm)	19.14	4.29	1000†
Cr	(ppm)	10.46	1.13	1000†
Zn	(ppm)	81.60	9.86	2500†
Co	(ppm)	4.24	0.68	NS
Mn	(ppm)	373.76	25.38	NS
B	(ppm)	15.00	1.03	NS
Ti	(%)	0.09	0.05	NS
Na	(%)	1.51	0.14	NS
Fe	(%)	2.67	3.55	NS
Al	(%)	3.38	0.34	NS
Pesticides				
captan	(ppm)	0.0052	0.0050	0.05-100*
total chlordane	(ppm)	0.0932	0.1190	0.03*
lindane	(ppm)	0.1810	0.2057	1.0-7.0*
total 2,4-D	(ppm)	0.0025	0.0033	0.05-1.0*

NS No Standard.
ND Not Detected.
† *Class I compost criteria, NYS DEC Part 360-5.3 (p) (1) (i).*
* *USDA tolerance levels for pesticides in food, 40 CFR Chapter 1, Part 180.*

Based on evidence from environmental monitoring program, communities can be strongly encouraged to develop composting facilities and begin recycling organic wastes.

Biochemical Oxygen Demand and phenols are both natural products of decomposition, but the concentrated levels generated by large scale composting should not be discharged into surface water supplies. Alternatives to surface discharge include such simple technologies as soil treatment, filter strips, or recirculation, so that sophisticated collection and treatment systems should not be needed.

These simple, low-cost treatment strategies have proven effective for a variety of wastewaters and organic wastes (Loehr et. al., 1979). Soil treatment forces the percolation of water through the soil profile, where these organic compounds can be adsorbed and degraded. Vegetative filter strips slow the motion of runoff water so that many particles can settle out of the water, while others are physically filtered and adsorbed onto plants. Recirculation would involve pumping the runoff water back into the compost windrows, where the organic compounds could further degrade and the water would be evaporated through the composting process. This last option should work very well during the initial stages of leaf composting, when water often needs to be added, but would not be appropriate if the moisture content of the compost was already high.

Leaf composting, in which decomposition rates are nitrogen limited, do not generate high levels of nitrates or other nitrogen compounds. however, compost facilities that manage high nitrogen materials such as grass clippings, or that use supplemental nitrogen to accelerate leaf decomposition, need to insure that excess nitrogen is not escaping in runoff. While many of the same simple treatment technologies described above would be effective for moderate levels of nitrogen, prevention is the best strategy. Maintaining the carbon to nitrogen ratio above 30:1 in the initial mix should insure low levels of nitrogen in runoff, and will also help minimize the odors which sometimes accompany grass clipping compost sites.

The current arbitrary restrictions on the distance between compost sites and neighboring water systems do not account for either the nature of the material composted or the type of runoff treatment system devised. Based on the information developed though this study, as well as a compost site monitoring program currently being implemented by the DEC, it may be possible to develop design and management guidelines that provide greater flexibility in siting facilities, and yet protect water quality even more effectively than at present.

The variety of other parameters monitored in this study do not appear to be problems for leaf composting facilities. The heavy metal content of the leaves was quite low, far below the levels permitted by the DEC, and thus did not affect the water, soil, or compost quality. Only four pesticides were detected in the finished compost, and these were all at the low end of the range for background values in suburban soils.

The fertilizer content of the compost was typical of compost products currently on the market. The only constraint that should be noted in the use of this compost is the relatively high pH of 8.2, which would not be recommended for acid loving plants. In general the compost should prove an excellent soil amendment for most landscape and gardening uses.

With the evidence from this environmental monitoring program in hand, communities can be strongly encouraged to develop composting facilities and begin recycling organic wastes. By designing sites which incorporate relatively simple water quality protection measures, compost facilities can become better neighbors in their local communities. The Croton Point Compost Site demonstrates that municipal leaf composting can be accomplished efficiently and economically, without sacrificing environmental quality. ■

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