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Highly Compacted Soils Improved by Compost Use

By Mary Schwarz, Nina Bassuk, Jean Bonhotal and Ellen Harrison

Livestock farms, particularly diary farms in New York State, are under increasing pressure to improve their manure management. Composting is one important option that can help to reduce odors and pathogens and enhance biosecurity on farms and produce a valuable product for use. Cornell Waste Management Institute and the Department of Horticulture at Cornell University, conducted a three-year long project designed to examine the use of manure-based compost as a soil amendment for severely disturbed construction sites. Funded by the New York State Energy Research and Development Authority, this research was conducted to explore markets for manure-based compost in New York State.

Compacted soils are the ubiquitous result of urbanization and the building process. Compacted soils have high bulk densities and low macroporosities that restrict root growth. Creating viable landscapes on severely degraded sites due to construction damage is a tremendous challenge for professionals in landscape architecture and horticulture.

During 2003-2004, a Cornell University class taught by Nina Bassuk (Horticulture Dept.) and Peter Trowbridge (Landscape Architecture Dept.) designed and installed a new landscape garden at Cornell University where soils had been severely degraded due to construction. This made an excellent test site for the use of composts during the remediation of the highly compacted soil. The objective of this project was to amend a compacted clayey soil with two types of compost in a landscape setting so that beneficial levels of soil density, aeration and drainage could be achieved. A new landscape was created on the site to take advantage of these improved conditions and plant growth was monitored.

Research conducted by A. Rivenshield and Bassuk at Cornell’s Urban Horticulture Institute in 2001, demonstrated that compacted soils can be made productive again if appropriate types and volumes of composted organic matter are incorporated. Soil bulk densities were reduced to below root restricting thresholds with the addition of 33% compost (by volume) in a sandy loam soil and 50% compost in a clay soil. With this in mind, a thorough characterization of the ‘before’ conditions at the site was performed, including soil texture and density, spatial variability, drainage, water-holding capacity, nutrient and microbial status. Soil from the site was taken to the lab and amended with two types of composts (poultry and dairy) at increasing levels to predict how much would be necessary to create beneficial conditions for plant growth. The dairy compost was manure, bedding and food scraps bulked with wood chips. The compost was made on a dirt pad in windrows with a high turning frequency. The poultry compost was poultry manure and bedding bulked with wood chips. This was also made on a dirt pad in windrows with a high turning frequency.

Soil was taken from the site and roughly sieved through an 8 mm sieve. Zero, 25, 50 and 75% compost of both types was added by volume to the soil. The soil was mixed and recompacted using a standard Proctor hammer protocol and tested for density, macroporosity and drainage. Four replicates of each type of compost-soil mixture were analyzed. Table 1 shows the bulk density and macroporosity of the initial soil tests run in the laboratory. Fifty percent amendment reduced the bulk density of the soil to below root inhibiting levels (1.45g/cc) for silty clay soil after re-compaction.

Table 1: Average bulk density and macroporosity for different volumes of soil and compost. Values followed by different superscripts in each column are significantly different ($p < 0.05$).

Compost	% Volume	Bulk Density	Macroporosity
None	0	1.81^{a}	0.59^{a}
Poultry	25	1.65^{b}	0.54^{a}
Poultry	50	1.51^{c}	1.24^{a}
Poultry	75	1.36^{d}	1.43^{a}
Poultry	100	1.22^{e}	1.49^{a}
Dairy	25	1.56^{bc}	0.84^{a}
Dairy	50	1.28^{de}	1.08^{a}
Dairy	75	0.91^{f}	1.55^{a}
Dairy	100	0.51^{g}	4.99^{b}

The original soil was taken from the site and amended with 50% compost (by volume). Half was amended with poultry compost and half with dairy manure compost and then returned to the site and added to a depth of 18”. The site was approximately 75 x 50 feet. It was divided into the “triangle” (site 1) and “Warren” (site 2). Both the poultry and the dairy manure compost amended soils were used in the triangle and Warren. Because this was a “real world” project seeking to improve a degraded landscape, there were no unamended control plots. Soil samples of the amended garden soils were taken in quadruplicate from the different site/compost combinations on 12/3/04, 11/3/05 and 9/21/06 and tested for density, macroporosity and drainage. The bulk density and the macroporosity remained constant over time indicating that the benefits of compost addition lasted over three growing seasons (Tables 2 and 3).

Table 2: Average bulk density of the soil at the different site/compost combinations over three years.

Date	Poultry Site 1	Poultry Site 2	Dairy Site 1	Dairy Site 2
12/3/04	0.81^{a}	1.13^{a}	0.85^{a}	1.01^{a}
11/3/05	0.67^{a}	1.12^{a}	0.82^{a}	0.98^{a}
9/21/06	0.80^{a}	1.15^{a}	0.97^{a}	0.94^{a}

Values followed by different superscripts in each column are significantly different ($p < 0.05$).

Table 3: Average macroporosity of the soil at the different site/compost combinations over three years.

Date	Poultry Site 1	Poultry Site 2	Dairy Site 1	Dairy Site 2
12/3/04	6.1^{a}	3.3^{a}	4.0^{a}	3.2^{a}
11/3/05	3.0^{a}	3.3^{a}	3.8^{a}	3.9^{a}
9/21/06	3.8^{a}	3.0^{a}	4.3^{a}	4.1^{a}

Values followed by different superscripts in each column are significantly different ($p < 0.05$).

The landscape is thriving and the bulk density of the soil remains below root inhibiting levels. The use of manure-based compost in soil remediation of construction sites can have lasting benefits for the growth and health of plants.

Soil before compost addition

Soil after compost addition

Before Remediation

Three years after initial planting

In conclusion, the use of high amounts of compost can transform severely compacted soils into soils that can support landscape gardens.