

RESEARCH BULLETIN

Developing environmental solutions for the future

Issue 3, Volume 3

Fall 2005

www.erefndn.org

Carbon Sequestration in Municipal Solid Waste Landfills

ABSTRACT: Long-term sequestration of carbon occurs in municipal solid waste landfills after anaerobic degradation.

In the United States, municipal solid waste (MSW) is composed of 40 to 50 percent cellulose, 9 to 12 percent hemicellulose, and 10 to 15 percent lignin on a dry weight basis, with cellulose and hemicellulose representing about 90 percent of the biodegradable portion of the MSW (Barlaz et al., 1989 and 1990). When MSW is buried in a landfill, a complex series of reactions occur in which anaerobic microorganisms decompose the major organic fractions of the waste to carbon dioxide (CO₂) and methane (CH₄).

Although cellulose decomposition in landfills is well documented, there remains significant uncertainty in the maximum extent of cellulose decomposition that can be realized under landfill conditions. Previous research identified refuse samples with cellulose concentrations as low as 1 percent and cellulose to lignin ratios below 0.1 (Barlaz, 2005). However, the extent of decomposition has not been reported with any consistency.

Barlaz (1998) conducted laboratory-scale degradation studies to quantify carbon sequestration for the major biodegradable components of MSW including grass, leaves, branches, food, coated paper, old newsprint, old corrugated containers, and office paper. A carbon storage factor (CSF) was calculated that represented the mass of carbon stored (not degraded) per initial mass of the component. The CSF for the MSW components ranged from 0.08 to 0.54 kg of carbon (C) sequestered per dry kg (Table 1).

Table 1. Carbon Storage Factors for Biodegradable Refuse Components

Refuse Component	CSF (kg C sequestered)
Grass	0.32
Leaves	0.30
Branches	0.38
Food	0.08
Coated paper	0.34
Old newsprint	0.42
Old corrugated	0.26
Office paper	0.05
MSW	0.22

Gardner, W.D. et al. (2004) collected field data on the decomposition of 19 to 29 year old wood products in two Australian landfills. The two landfills were operated under different conditions. Waste in the 19-year old landfill was compacted during placement and methane was collected, while waste in the 29-year old landfill was not compacted, methane was not collected, and leachate was recirculated. Wood products were collected from both landfills and tested for wood properties and chemical composition. Carbon loss in the 19 and 29-year-old landfills was estimated to be 4.1 and 2.5 percent, respectively.

These studies, as well as the literature, indicate that significant carbon sequestration occurs in landfills because of the limited degradation of wood products. These findings

are important because they are used in the development of national greenhouse gas emission inventories. In addition, carbon-trading protocols require defensible data on which trades and purchases are based.

Because further research is needed to fully document the rate and extent of decomposition of wood products in landfills, North Carolina State University held a workshop on May 24-25, 2005 to develop strategies and methodological principles to guide future research into the decomposition of wood and paper products in U.S. and Australian landfills. The objective of the workshop was to develop realistic estimates of methane production and carbon sequestration from individual wood and paper products buried in landfills. Experts from both the U.S. and Australia attended the workshop.

The first two days of the workshop were devoted to presentations and discussion of various strategies and analytical techniques that could be used to better estimate the extent of decomposition in landfills, while the third day was devoted to the excavation of wood and paper products from two local landfills. Both wood and paper products in good condition, ranging in age from 5 to 18 years, were recovered. Samples were collected for analyses, which gave workshop participants an opportunity to test some of the new analytical techniques discussed during the first two days of the workshop.

References:

Barlaz, M.A. 1998. Carbon storage during biodegradation of municipal solid waste components in laboratory-scale landfills. *Global Biochem. Cycles* 12(2):373-380.

Barlaz, M.A., R.K. Ham, and D.M. Schaefer. 1989. Mass balance analysis of decomposed refuse in laboratory scale lysimeters. *J. Environ. Eng. N.Y.* 115:1088-1102.

Barlaz, M.A., R.K. Ham, and D.M. Schaefer. 1990. Methane production from municipal refuse: a review of enhancement techniques and microbial dynamics. *Crit. Rev. Environ. Control.* 19:557-584.

Barlaz, M. A., 2005. Forest products decomposition in municipal solid waste landfills. Accepted for publication, *Waste Management*.

Gardner, W.D., F. Ximenes, A. Cowie, J.F. Marchant, S. Mann, and K. Dods. 2004. Decomposition of wood products in Lucas Heights landfill facility. 3rd Intercontinental Landfill Research Symposium. Japan.



The North Carolina State University (NCSU) workshop was funded in part by a grant from the Environmental Research and Education Foundation to NCSU. For further information on the workshop, contact Dr. Morton Barlaz at 919-515-7676; barlaz@eos.ncsu.edu; <http://people.engr.ncsu.edu/barlaz/>.