Strategies for Reducing Degradable Organic Wastes in Landfills

Issue Statement

Current landfill designs and practices do not provide for degradation of landfilled organic wastes within a defined and reasonable timeframe. Undegraded organic wastes can potentially cause future environmental or economic impacts if the landfill gas and leachate collection and containment systems (cap and/or liner) fail at some time in the future. Potential economic burdens and environmental risks associated with these undegraded wastes will be largely borne by future generations. Better landfill designs and organic management practices should be identified and implemented to provide for organic waste degradation within a reasonable timeframe.

"Reasonable timeframe" means within the lifetime of the people who generate the waste.

"Economic burdens" means costs to manage gas and leachate, to maintain the slopes and cover, to perform environmental monitoring, and to control access.

"Environmental risks" includes potential contamination of groundwater and surface water, air quality degradation, greenhouse gas impacts, explosive gas generation, and/or land instability.

Note: This table represents an attempt by the Landfill Stability Workgroup to identify a wide range of techniques relevant to reducing the amount of degradable organics in Wisconsin landfills. The workgroup recognizes that it is likely an incomplete list. It is intended as a framework for further discussion of methods that might be applied in Wisconsin as part of plans to be submitted by landfill operators for significantly reducing the amount of degradable organic material remaining after site closure. As such, it includes statements that are based on workgroup members' experience and opinions, and research using popular and peer-reviewed scientific literature and publications by government and private organizations in the U.S. and abroad.

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Waste Stabilization Strategies	Applicable Feedstocks*	Pros	Cons	Possible Regulatory Steps Toward Implementation	Current Status
Anaerobic Bioreactor Landfill	All organic wastes (47.3%); note that lignin in wood and paper not effectively degraded in anaerobic environment	• Conceptually simple, straightforward to implement; most similar to current operations • Methane generated faster at higher volumes in shorter periods for energy recovery • Stabilization of leachate • Stabilization of gas • Stabilization of landfill settlement • Shortens long-term care period – Quicker return of property to productive end use. • Reduces leachate treatment costs • Allows the disposal of specific liquid wastes without having to solidify first	• Need additional liquid streams to reach optimal moisture content (45%) – Need to add 40-80 gallons of liquid per cy • Requires a RD&D approval to add outside liquids • Need to manage increased gas flow sooner; may require redesign of gas extraction system • Ammonia concentrations in leachate may increase • Process can be slowed by cold weather • Potential for seeps and odors that must be managed • Moisture distribution requirements present operational complexities and challenges • Technology in demonstration stage • Higher cost than current “dry tomb” approach	• RD&D approval to allow addition of outside liquids • Change regulations to allow delaying installation of final cover systems greater than 2 years to account for increased settlement and to allow additional moisture into the waste mass. • RD&D approval to allow alternative caps that provide additional moisture addition • Change regulations to allow refilling of slopes or designed overfills to account for increased settlement	• Currently being practiced at sites in other states with CRADA approvals or sites with a large supply of leachate • About 15 full-scale demonstration projects/ commercial operations in US and Canada

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Aerobic Bioreactor Landfill	All organic wastes (47.3%)	• No methane emissions • Process is very accelerated and typically takes less than 2 years • Stabilization of leachate • Stabilization of gas • Stabilization of landfill Settlement • Shortens long-term care period– Quicker return of property to productive end use. • Reduces leachate treatment costs • Allows the disposal of specific liquid wastes without having to solidify first • Allows degradation of materials that only degrade in aerobic conditions (e.g., lignin in paper)	• No methane generated for energy recovery • Need additional liquid to control large amounts of metabolic heat and evaporative water loss • Requires a RD&D approval to add outside liquids • Higher capital and operating costs • Potential for fires • Potential for seeps and odors that must be managed • Not easily implemented at high volume landfills because larger area is required • Issues with patented technology • Technology is in research and demonstration stage • Operation is complex • Moisture distribution requirements present operational complexities and challenges • High energy input requirements	• RD&D approval to allow addition of outside liquids • Change regulations to allow delaying installation of final cover systems greater than 2 years to account for increased settlement and to allow additional moisture into the waste mass. • RD&D approval to allow alternative caps that provide additional moisture addition • Change regulations to allow refilling of slopes or designed overfills to account for increased settlement	• Currently being practiced at sites in other states with CRADA approvals or sites with a large supply of leachate • A few (3-5) full-scale demonstration projects in progress in US or Canada • Some experience in Europe

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Hybrid Aerobic/Anaerobic Landfill	All organic wastes (47.3%)	• Combines the operational simplicity of the anaerobic process with the treatment efficiency of the aerobic process • Rapid decomposition of food waste and early methane generation • Gets decomposition process past acid phase • Aeration portion heats up waste mass and speeds up process • Facilitates operation in cold weather • Expanded potential for destruction of VOCs, HAPs, and NMOCs • Stabilization of leachate • Stabilization of gas • Stabilization of landfill Settlement • Shortens long-term care period– Quicker return of property to productive end use. • Reduces leachate treatment costs • Allows the disposal of specific liquid wastes without having to solidify first	• Need additional liquid streams to reach optimal moisture content (45%)– Need to add 40-80 gallons of liquid per cy • Requires a RD&D approval to add outside liquids • Need to manage increased gas flow • Higher capital and operating costs • Potential for fires • Potential for seeps and odors that must be managed • Ammonia concentrations in leachate may increase • Issues with patented technology • Moisture distribution requirements present operational complexities and challenges • More complex operation due to dual operation and changing areas • Technology still in the research and demonstration stage	• RD&D approval to allow addition of outside liquids • Change regulations to allow delaying installation of final cover systems greater than 2 years to account for increased settlement and to allow additional moisture into the waste mass. • RD&D approval to allow alternative caps that provide additional moisture addition • Change regulations to allow refilling of slopes or designed overfills to account for increased settlement	• Currently being practiced at sites in other states with CRADA approvals or sites with a large supply of leachate • Waste Management has a full-scale demonstration project at Outerloop LF in KY • Demonstrated in Wisconsin at Waste Management's Metro LF in Franklin

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Treatment Layers Within a Lined Landfill System (adding layers of material above the leachate drainage layer specifically designed to remove targeted contaminants form the leachate)	All organic wastes (47.3%); note that lignin in wood and paper not effectively degraded in anaerobic environment	• Reduces leachate toxicity ◦ For treatment ◦ For release after liner failure	• Does not enhance degradation of organics • Hard to match attenuation layer to leachate loading rates/changes with time • Don't know how geochemical changes will affect layers • Could add significant capital expense • Permeability of layers could negatively impact landfill hydraulic systems	• Allowed under current rules	• Experimental as a design concept • Used to a limited extent at hazardous waste landfills
Treatment Layers in an Unlined Landfill System (This should not be confused with "natural attenuation" design which relied on in-place soils.) These designs rely on engineered layers to perform specific functions (e.g., tire chips to remove VOCs, alkaline fly ash to bind up heavy metals)	All organic wastes (47.3%); note that lignin in wood and paper not effectively degraded in anaerobic environment	• Less expensive than lined system • Low-maintenance • Doesn't depend on containment liners which can fail at the end of their useful life	• Does not enhance degradation of organics • Better suited to mono waste streams • Likely only applicable to small landfills • May violate groundwater standards due to wide range of potential contaminants in leachate • Hard to match attenuation layer to leachate loading rates/changes with time • Don't know how geochemical changes will affect layers	• Would require Federal rule change for alternative liner • Would require exemption from existing State requirements	• Experimental as a design concept

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Waste Stabilization Strategies	Applicable Feedstocks*	Pros	Cons	Possible Regulatory Steps Toward Implementation	Current Status
MSW Composting	All organic wastes (47.3%).	• Quickly reduces readily degradable organics • Utilizes controlled reaction, typically in a reaction vessel or building • Provides volume reduction prior to landfilling • Possible reuse of material (e.g., to stabilize sewage sludge)	• High capital and operational costs	• Allowed under current rules	• Used at Columbia County in WI • Widely used in other states and Europe • Generally used to produce a product, rather than as a precursor to landfilling
Anaerobic Digestion	All organic wastes (47.3%), or can be targeted towards specific organic portion of waste stream such as food waste; note that lignin in wood and paper not effectively degraded in anaerobic environment	• Utilizes controlled reaction vessel • Methane gas collection and utilization	• Slower degradation than aerobic reaction • Potential odor concerns with sludge	• Allowed under current rules	• Very limited pilot-scale use Wisconsin • Current pilot test for food waste in Milwaukee; another pilot project likely to get grant funding soon for processing food waste separated from MSW • Europe installed capacity at ~2.8 million tons/year
Catalytic Cracking	Polymeric plastics not containing chlorine: • PET btls (.4%) • HDPE btls (.4%) • polystyrene (.5%) • other ctrs (1.6%) • plastic film (4.0%)	• Significant energy savings over landfilling** • Recovers energy, replacing other fossil fuels	• Little emissions info • Primarily applicable to polyolefin plastics – narrow spectrum of feedstocks (best suited to separated waste) • Susceptible to deactivation of catalyst by small amounts of chlorine from PVC	• Allowed under current rules	• Technology (using waste plastics) is well established in petroleum industry • A handful of MSW-derived waste facilities have been constructed by Plastic Energy LLC; one is proposed for Hanford, CA.

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Fermentation (incl. hydrolysis)	All organic wastes (47.3%); note that lignin in wood and paper not effectively degraded in anaerobic environment	• Produces energy, replacing other fossil fuels; significant energy savings over landfilling** • Produces useful byproducts from undigested lignin and cellulose • Environmental impacts widely accepted to be low and controllable • Extends landfill space	• Would require changes in collection and processing infrastructure • Resources lost to commerce • Generally better for specific high-sugar waste components, such as cellulose in paper, versus entire waste stream	• Allowed under current rules	• Fully commercial for sugar and starch based biomass feedstocks • Two planned facilities in US for cellulosic MSW feedstocks
Incineration	All organic wastes (47.3%) plus plastics (10.5%), tires (0.6%), residual/composite paper (2.5%), diapers (1.8%), remaining textiles (1.2%), carpet/padding (2.7%), and residual/composite organics (2.0%)	• Can produce energy, replacing other fossil fuels; significant energy savings over landfilling** • Reduces the volume of material to be handled at the landfill	• Need to develop infrastructure • Expensive • Can result in an ash with more mobility of toxics (can be hazardous waste) • Material cannot be reused by commerce • Unpopular with many citizen groups due to perceived environmental impacts • Air pollution concerns	• Allowed under current rules	• Being done in some European countries, and is growing there. Fairly common in the US. • In WI, current operations include Barron Co incinerator and LaCrosse Co RDF burned at XL Energy plant

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Waste Stabilization Strategies	Applicable Feedstocks*	Pros	Cons	Possible Regulatory Steps Toward Implementation	Current Status
Plasma Technology	All wastes	• May generate net positive power if large enough throughput • Theoretically applicable to all kinds of waste • High temps lead to more complete destruction • Solid residue is a slag, allowing potential beneficial uses	• Emissions require treatment (NOx, SOx, some metals) • Volatilizes metals, requiring additional air emissions controls • Resources in waste are lost to commerce • Very high capital cost and high operating cost; may be offset by sale of fuel gas produced if market is there • Less efficient than direct heating due to need to produce electricity for arc • Best fit as a small-scale niche solution (e.g., med waste) versus entire waste stream due to cost	• Allowed under current rules	• In demonstration phase; small MSW plants operational in Japan; Startech under contract for 2 large plants in Poland; very small HW (Lorton, VA) and medwaste (Honolulu, HI) plants in US. Also a small demonstration plant in CT. • Canadian Navy using this technology
Pyrolysis	All organic wastes (47.3%) plus plastics (10.5%), tires (0.6%), residual/composite paper (2.5%), diapers (1.8%), remaining textiles (1.2%), carpet/padding (2.7%), and residual/composite organics (2.0%)	• Could potentially produce useful fuels and chemical feedstocks • Accepts a variety of waste inputs • More efficient and fewer emissions than straight waste incineration	• Economics require large waste throughputs • Require relatively homogeneous inputs • Economics depend on niche markets for products • Preprocessing (drying, shredding) likely required • Air emissions require controls • Loss of some resources • Perception that this is incineration • Can produce end product that is hazardous waste	• Allowed under current rules	• Changing World Technologies operating large turkey waste processing facility in Carthage, MO. • Small scale facilities operational and larger scale facilities planned in CA, NV • Number of facilities operational or planned in Europe, Asia; many are niche operations or receive public subsidies

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Waste Stabilization Strategies	Applicable Feedstocks*	Pros	Cons	Possible Regulatory Steps Toward Implementation	Current Status
Gasification	All organic wastes (47.3%) plus plastics (10.5%), tires (0.6%), residual/composite paper (2.5%), diapers (1.8%), remaining textiles (1.2%), carpet/padding (2.7%), and residual/composite organics (2.0%)	• Significant energy savings over landfilling** • Produces useful syngases or fuel • Accept a variety of waste inputs • More efficient and fewer emissions than straight waste incineration	• Economics require large waste throughputs • Require homogeneous inputs • Economics depend on niche markets for products • Preprocessing (drying, shredding) likely required • Air emissions require controls • Loss of some resources • Perception that this is incineration	• Allowed under current rules	• Several dozen facilities operational or planned in Europe, Asia; many are niche operations or receive public subsidies • Large (1200 tpd) operating facility using up to 80% waste in Germany
Waste Shredding	Potentially applicable to all wastes except materials that would damage shredding equipment (e.g., concrete, some metals)	• Uniformity of waste increases compaction • Consistent moisture distribution	• Significant explosion potential • High equipment maintenance • Major safety issues with in-landfill pull-behind type of shredder	• Allowed under current rules	• No longer used in WI (except LaCrosse RDF)
Landfill Structural Design and Operation Changes:					
▪ Delay Final Cap Installation	All organic wastes (47.3%); note that lignin in wood and paper not effectively degraded in anaerobic environment	• Allows additional moisture to reach waste mass to promote decomposition • Allows for settlement to occur before installing final cover system	• Gas system design and operation may need to be modified and temporary systems may be required • Increased leachate generation • May have added cost to install/remove intermediate cover	• Change regulations to allow delaying installation of final cover systems greater than 2 years to account for increased settlement and to allow additional moisture into the waste mass. • Change regulations to allow refilling of slopes or designed overfills to account for increased settlement	• Other states allow these practices

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▪ Installation of Alternative Caps	All organic wastes (47.3%); note that lignin in wood and paper not effectively degraded in anaerobic environment	• Allow some moisture into the waste mass to aid in stabilization • Accommodate settling and subsidence so that the cover's integrity is maintained • Prevent migration or release of significant quantities of landfill gases (relative to no cap) • Cost savings over Subtitle D Covers • For bioreactor operation, additional water can be added through the cap via over-irrigation in the early post-closure years • Easier than a Subtitle D cover to install in a two-stage approach with an initial thinner "leakier" cover followed by a thicker cover to minimize long-term leachate generation	• More leachate to manage • Potential for seeps • Potential for odors	• RD&D approval to allow alternative caps that provide additional moisture addition	• Other states have been approving Alternative Caps

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▪ Intensive leachate recirculation (similar to anaerobic bioreactor landfill but using only on-site leachate in the process)	All organic wastes (47.3%); note that lignin in wood and paper not effectively degraded in anaerobic environment	• Simple, easy to implement; most similar to current operations • Methane generated faster at higher volumes in shorter periods for energy recovery • Stabilization of leachate • Stabilization of gas • Landfill settlement occurs earlier and faster • Shortens long-term care period – Quicker return of property to productive end use. • Reduces leachate treatment costs • Reduces transport/handling of leachate • Provides leachate treatment for organic components	• Need to manage increased gas flow • Ammonia concentrations in leachate may increase • Process can be slowed by cold weather • Lack of optimal moisture slows process or limits completion of degradation • Potential for developing problems with leachate seeps, head build up, or odors that must be managed	• Allowed under current rules	• Currently being practiced in Wisconsin and other states • Relatively common across US
Increased Diversion of Organics for Composting:					

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▪ Yard material	Remaining landfilled yard material (1.3%)	• Already existing law • Reduces the acid phase of landfill decomposition from grass • Reduces methane release to the atmosphere from degradation of the grass in landfills above the zone of influence of gas extraction system • High on waste hierarchy • Recovers humus	• There will be a reduction in recoverable methane generation at landfills • Potential environmental or odor issues with composting if improperly managed • Requires separation at source and separate collection/composting (unless reused on-site by generator)		• Already law in Wisconsin; common throughout the US. • Has effectively removed vast majority of yard material from landfills in WI

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Waste Stabilization Strategies	Applicable Feedstocks*	Pros	Cons	Possible Regulatory Steps Toward Implementation	Current Status
▪ Food	Landfilled food wastes (10.2%)	• Reduces the need for daily cover; less food at the landfill means both fewer odors and fewer flies and birds • Reduces the acid phase of landfill decomposition • Reduces methane release to the atmosphere from degradation in a landfill above the zone of influence of gas extraction system • High on the waste hierarchy • Can recover a substantial proportion of the food at home or through garbage disposal units; with disposal units, this can result in the recovery of both the organics and in the generation of methane gas at the wastewater treatment plant • With food out of the waste system, collection frequency for solid waste collection can be reduced • Recovers humus	• Need a system to collect, recover the food • Food composting is difficult to do without odor and nuisance problems • There will be a reduction in recoverable methane generation at landfills • Use of garbage disposal units may add to loading problems at the wastewater treatment plant. • Siting processing facilities may be difficult due to public perceptions, odors, noise, etc.	• Establish standards for end products for Wisconsin	• Common in Europe and parts of Asia (Taiwan recently announced a mandatory requirement by 2006); growing rapidly in North America, such as Nova Scotia, the San Francisco area , Portland and elsewhere. Dane County has a priority to recover food residues and has published a report on this topic, with an extensive bibliography of several hundred articles found in the past few years.

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Waste Stabilization Strategies	Applicable Feedstocks*	Pros	Cons	Possible Regulatory Steps Toward Implementation	Current Status
▪ Compostable Paper	Compostable paper (4.8%) plus other recyclable paper currently being landfilled (16.0%)	• Will reduce litter at landfills • High on waste hierarchy • Recovers humus	• Need to expand the infrastructure to collect and process the material • Will reduce recoverable methane gas generation at landfills • VOCs can be released to air from aerobic breakdown of lignin in paper	• Establish standards for end products for Wisconsin	• Done in Europe, especially in combination with food. Nova Scotia also does with food. • Oneida County pilot project included wax coated OCC and food waste

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▪ Food and compostable paper (composted jointly)	Landfilled food waste (10.2%) plus compostable paper (4.8%) plus recyclable paper currently being landfilled (16.0%)	• High on waste hierarchy • Food/paper mixture will have less odor problems than a food-alone system • Recovers humus • Reduces the need for daily cover; less food at the landfill means both fewer odors and fewer flies and birds • Reduces the acid phase of landfill decomposition • Reduces methane release to the atmosphere from degradation in a landfill above the zone of influence of gas extraction system • High on the waste hierarchy • Can recover a substantial proportion of the food at home or through garbage disposal units • With food out of the waste system, collection frequency for solid waste collection can be reduced	• Need to develop an infrastructure to collect and process the material • Will reduce recoverable methane gas generation at landfills • Siting processing facilities may be difficult due to public perceptions, odors, noise, etc.	• Establish standards for end products for Wisconsin	• Europe, Nova Scotia

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Increased Diversion of Hazardous Materials (e.g., electronics, HHW)	Problem wastes including televisions, electronics, batteries (7.7%) plus household hazardous wastes (0.6%)	• Protects micro-organisms in the landfill or compost from some toxics, such as metals • Reduces toxic emissions from landfills	• Does not directly contribute to degradation of organic wastes – protective measure only • Will result in substantial costs; need to find a source of revenues to cover these costs	• Require/promote manufacturer responsibility	• Municipalities have set up or contracted for clean sweep collection programs in many places, including throughout Wisconsin, however, private landfill owners often do not set up such systems.
Diversion of Wood/Paper for Energy Recovery	All paper (20.8%) plus untreated wood (12.8%)	• Can replace other fuels • Reduces landfill disposal rate • If implemented, may also allow burning of plastics for energy recovery	• Will need to develop infrastructure for collection • Will need to develop infrastructure for combustion • Contributes to global climate change gas emissions relative to sequestering carbon in a landfill • Prevents organic material from being used to improve soil	•	• Not common, but several firms in Wisconsin pelletize scrap paper/mill waste/wood for use as a fuel and several utility and industrial boilers (such as Minergy) burn wood scrap for energy. Contacts include Fox Valley Material LLC in Neenah, Pellet America Corp. in Appleton and the former Fiber Recovery plant in Wausau.
Increased Paper Recycling	Newsprint (1.9%), high-grade paper (1.4%); magazines/catalogs (1.0%), recyclable cardboard (4.0%), boxboard (0.7%), and mixed recyclable paper (4.2%)	• Markets are available • Builds upon the existing infrastructure • High on waste hierarchy • Returns resources to commerce, where it can be reused multiple times • Removes newsprint, which does not bio-degrade well in anaerobic conditions	• Will need the participation of generators, RUs, MRFs • Will reduce methane gas recovery at landfills • Requires separation at the source and in collection	•	• A number of Wisconsin communities are collecting mixed paper; both Milwaukee's and Madison's new contract and system will include this material. • High priority of the Council on Recycling • Market prices very good

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Upstream Waste Reduction	Unknown	• Highest on waste hierarchy • Reduces landfill disposal rate • Can save money for the generator on product purchase as well as waste management costs • Reduces collection needs	• Will need to involve manufacturers, generators • Hard to have control or measure results on an individual facility basis	•	•

* Percents indicate approximate percent of waste accepted by MSW landfills in Wisconsin as determined in 2002 Statewide Waste Characterization Study. "All organic wastes" includes paper (20.8%), yard waste (1.3%), food waste (10.2%), untreated wood (12.8%), and non-synthetic portion of textiles (assumed at half of 2.4%, or 1.2%), for a total of 47.3% of waste landfilled at MSW landfills.

** Life-cycle energy savings relative to landfills; source is draft "Life Cycle and Market Impact Assessment of Waste Conversion Technologies," April 2004 report to the California Integrated Waste Management Board, at www.ciwmb.ca.gov/Organics/Conversion/Events.