West Coast Forum Research Work Group Topic 8 – Organics

Summary of Research Findings and Gap Analysis

Topic 8: Life cycle analyses of organics diversion and disposal strategies

RESEARCH QUESTION(S)

- What (ideally quantitative or semi-quantitative) life-cycle analyses are available to compare the GHG benefits and impacts of composting, anaerobic digestion, other energy recovery technologies, and landfill disposal?
- Are such analyses complete or comparable? Where are they lacking?
- How sensitive are the results (identification of optimal vs. sub-optimal pathways) to different local conditions as well as different modeling assumptions (e.g. energy displaced by waste-to-energy, treatment of land-use related fluxes including carbon storage in landfills, use of 20-year vs. 100-year global warming potentials, etc.)?
- Which portions of the life-cycle of these strategies are not accounted for in current analyses and therefore lead to possibly skewed comparisons in current literature and policy?

KEY FINDINGS[1]

General

According to the EPA, the organic fraction of municipal solid waste – food scraps and yard trimming – comprises over 25% of the total waste generated (EPA, Basic Information about Food Waste). Options for managing organic wastes include:

Landfill

Landfilling remains the standard disposal method for MSW in most of the US. Lacking legislation limiting organic disposal, the US has been slower to work on diversion (Levis et al, 2010). Disposal of organics with the remaining solid waste fraction increases greenhouse gas (GHG) emissions from landfills but provides some carbon sequestration potential. Improvements in landfill gas capture systems have decreased the GHG emissions. However, fast decomposition of organics leads to rogue emissions prior to the installation of capture systems. Landfills differ in whether they capture and flare biogas, use biogas as a fuel, or use biogas for electricity. Any biogas capture offsets other fuel usage and thus decreases GHG emissions at both stages.

Composting

Composting includes both home, or decentralized composting, and centralized composting. Home composting includes all composting methods in which individuals compost their organic waste

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[1] *This research summary includes resources from a literature review compiled by ICF International for the Forum's Research Work Group as well as additional independent research by intern Jill Arnow.*

themselves. Decentralized composting cannot be considered a single technology and will never become a comprehensive solution to organic waste diversion due to barriers to participation for apartment dwellers and industry (Andersen et al, 2010). Supplemental technologies must still be used for the partially- and non-participatory population. In addition, the variation in participation makes quantification of decentralized composting difficult. Environmental advantages to decentralized composting include landfill diversion (Eriksson et al, 2005), decreased emissions from collection and transport (WHO), and that no water, electricity, or fuels are used in the process. The resultant compost is used at home, improves soil quality, and decreases the need for fertilizers. While CH_4 emissions are of concern, these levels are within the range of centralized composting.

Large-scale composting facilities vary in their designs, each resulting in different emissions and byproducts. Some examples of types of centralized aerobic composting systems include windrows, aerated static piles, gore cover systems, tunnel composting and in-vessel composting. Like decentralized composting, centralized composting diverts material from landfills however, it requires transport of materials both at collection and distribution of the resultant compost. Most centralized compost facilities require electricity for turning the stock, addition of bulking material, and water for wet digestion process. Methane capture is possible with centralized composting but less methane is trapped with composting than with anaerobic digestion (Levis and Barlaz, 2011).

Anaerobic Digestion

In the United States, the majority of anaerobic digestions (AD) systems are used to stabilize wastewater solids. Many more AD systems designed for solid waste management exist in Europe due to directives limiting landfilling of organic wastes in Europe. Classifications of AD are based on the content of the feedstock, the number of operational stages, the operating temperature, and the method of introducing feed. European countries generally prefer single-stage AD (CalWaste, 2008). Anaerobic digestion diverts material from landfills, and captures and reuses most methane. Drawbacks include transport of materials to and from the facility and capital investment in new AD facilities.

Incineration

Incineration can be carried out with or without separation of the organic fraction of the MSW (OFMSW). Incineration can provide heat recovery and power generation. Resulting pollutants from incineration include NO_x, dioxins, and SO_2 and ash by-products. Most incinerators in Europe are sited closer to cities, decreasing transportation effects. However, there has not been large-scale adoption of incineration in the United States.

Other methods

The literature presents several other techniques for disposal of the OFMSW that do not fit into other classifications.

- **Food scraps used for animal feed**. A life-cycle analysis from Korea, where landfilling food scraps is illegal, presents using food waste as animal feed as an option (Kim and Kim, 2010).

- **In sink food waste processors**. Marashlian et al (2005) indicate the use in sink disposals increase use of water, decrease the landfilling and transport of waste, and increase demands on wastewater treatment plants.

- **Co-digestion**. By combining the OFMSW with an agricultural or wastewater anaerobic digestion system, a municipality can gain the benefits of AD without building their own system. This takes advantage of excess capacity and delays the capital expenditures required to build a separate AD plant.

- **Reduction of food waste.** Methods for reducing food waste, including rescuing edible foods and reducing home food waste, are not included in life-cycle analysis discussions but are an important aspect to the organic waste diversion discussion.

What is Life-cycle Analysis?

Life-cycle analysis creates a standardized method for studying cradle to grave impacts of a system, product, or a process. For organic waste disposal, LCA's are very effective for comparing different disposal or diversion options within one location. For example, a LCA study can compare impacts of switching from landfilling to anaerobic digestion or composting.

KEY FINDINGS

The literature includes many life-cycle analyses (LCA) on the disposal of organic waste. While most LCAs are complete analyses, the predominant value of an LCA is in choosing the appropriate disposal/diversion method within a municipality. Some conclusions can be drawn from the LCAs:

- Landfilling organic waste without gas recovery is the worst option for greenhouse gas emissions; anaerobic digestion tends to capture the most emissions. Organics decompose faster than the non-organic waste and emit methane soon after landfilling and is often missed by landfill gas recovery systems. However, landfill gas recovery can be a good stepping stone until better options are available.

- Utilizing existing municipal wastewater treatment or agricultural waste treatment for the organic fraction of municipal waste can be a good option when available. Often these systems have untapped capacity and can be accessed with lower capital expenditures.

- Methane recovery can decrease the overall global warming potential (GWP) of the waste system. The decrease in GWP is greatest in areas where the recovered methane, from landfills or other disposal methods, replace coal-generated electricity. Replacing fossil fuel-derived transportation fuels with fuels from recovered methane also decreases the GWP of the solid waste system.

- External factors/boundary issues beyond the method of disposal tend to dominate the global warming impacts more than the disposal/diversion method chosen. As mentioned above, the value of WTE fuels, along with additional transportation miles for source separation of waste, and the use of compost as a replacement for fertilizer are all included in the LCAs. These processes often emit more GHGs than the actual decomposition of materials.

- Carbon sequestration is highest in landfill and composting. Composting provides added GHG benefits by displacing the production and use of fertilizers. However, transportation of finished compost must be included in the LCA.

- Disposal/Diversion priorities vary between countries. For example, the European Union requires diversion from landfill in part due to physical constraints. As a result, combustion and anaerobic digestion are preferred methods of organic disposal in Europe. In Korea, it is illegal to landfill food scraps so this waste is diverted to composting, anaerobic co-digestion with sewage sludge, and use as animal feed.

GAPS ANALYSIS

The literature review identified both gaps in knowledge and limitations of using LCAs for decision making about organic waste disposal options. There are many LCAs, each of which is complete on its own. However, the LCAs are rarely comparable or generalizable.

Comparability and Generalizability

Municipal waste LCA studies are designed to compare different disposal scenarios within one municipality; their application to other municipalities is limited.

Factors limiting comparability are:

- Inconsistent units of measurements - for example, using municipal area instead of volume of waste,
- Different characterization of organic waste – for example, whether there are consistent subcategories for food waste,
- LCA tool used for analysis,
- Underlying model assumptions and boundary conditions.

Factors limiting generalizability are:

- Local conditions – for example, transportation involved in waste disposal and energy replaced by WTE capture,
- Choice of scenarios – comparing situations that are location specific.
- Decision drivers – what’s making them make the choices they make, for example regulations favor landfill diversion over GHG emission considerations.

Recommendations

Create a standard functional unit for LCAs of organic waste. For LCAs of organic waste to be comparable, there must be standards for definitions of models and units of measurement.

Create standard waste characterization categories that are used by all states and countries and all LCA tools. Using standard waste classifications will improve the ability to compare studies.

Improve methodologies for calculating emissions for all disposal methods. Getting accurate measurements of emissions can be difficult for many disposal methods. Improving the measurements will improve the ability to compare GHG emissions of each disposal method. Should include better measurements of oxidation rate of methane in landfills and landfill efficiency.

Perform a meta-analysis of all LCA studies. It may be possible to convert all studies into similar units and perform a meta-analysis providing greater data on disposal options.

Best Practices Study – Organics Collection and Disposal. Some of the topics for collection include: source separation, pick up frequency, participation rates, contamination rates, and categories of materials included. Best practices study for disposal comparing the GHG impacts within different disposal systems. Currently, nothing compares all disposal options for organics.

Best Practices Studies – Impact of Regulation. Regulation plays a key role in pushing organic diversion methods, for example, the EU regulations have just about maximized their potential GHG savings while the US lags behind. Study of what works best for decreasing GHG emissions.

Best Practices Study - Impact of consumer behavior. Consumers play a critical role in organic diversion. Study best practices around the world for improving participation in organic diversion.

Best Practices Study – Level of Detail Required for LCA Understanding the point of diminishing returns for detail in an LCA to maximize applicability.

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