Waste to Wetlands

Organic Waste in the 21st Century

Robin Croen

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An Investigation of Municipal Solid Waste Management in the United States

A senior project presented to the faculty of Landscape Architecture at the University of California, Davis, in fulfillment of the requirements for the degree of Bachelors of Sciences in Landscape Architecture.

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Abstract

Since the Industrial Revolution, annual municipal solid waste (MSW) generation has grown to staggering amounts. The majority of MSW is discarded to landfills where organic materials are broken down by microbial action, resulting in the release of harmful emissions, such as the green house gas methane, into the environment. If organic wastes were removed from the greater waste flow and isolated into their own waste flow, it would be possible to recover valuable resources such as fertilizer, mitigate the release of landfill emissions, and reduce the overall volume of waste discarded to landfills. Analysis of the municipal solid waste management (MSWM) system in the United States uncovers discrepancies in how effective different fractions of MSW are recovered and shows that food scraps are the least recovered MSW fraction. By adapting existing waste collection techniques such as incentives-based recycling it would be possible to alter the existing MSWM system to recover food scraps. By adapting existing wastewater wetland facilities it is possible to utilize the relationships of microbial action and organic particulates found in natural wetlands to break down municipal organic waste in an environmentally sound fashion. Constructed wetlands can recover organic waste while restoring fragile wetland ecosystems, creating habitat for threatened wetland wildlife, and providing recreational and educational space for people.

Acknowledgements

I would like to thank my friends and family for their support and encouragement, my fellow Landscape Architecture classmates for their invaluable ideas, suggestions, and company, and last but certainly not least, my Senior Project Committee Members - Claire Napawan, Jeff Loux, and Stephen Wheeler - for their profound guidance.

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Definitions

actinomycetes
Any of various filamentous or rod-shaped, often pathogenic microorganisms of the order Actinomycetales that are found in soil and resemble bacteria and fungi

anthropogenic
Originating in human activity.

biodegradable
Capable of being decomposed by bacteria or other living organisms.

biofertilizer
A substance which contains living microorganisms which, when applied to seed, plant surfaces, or soil, colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant.

biogas
Gaseous fuel, esp. methane, produced by the fermentation of organic matter.

bioreactor
An apparatus or system in which a biological reaction or process is carried out, esp. on an industrial scale.

biowaste
A type of waste, typically originating from plant or animal sources, which may be broken down by other living organisms.

compost
Decayed organic material used as a plant fertilizer.

cogeneration
Cogeneration (also combined heat and power, CHP) is the use of a heat engine or a power station to simultaneously generate both electricity and useful heat. It is one of the most common forms of energy recycling.

disposable
An article designed to be thrown away after use.

dump
A site for depositing garbage.

Environmental Protection Agency
The U.S. Environmental Protection Agency (EPA or sometimes US EPA) is an agency of the federal government of the United States charged to protect human health and the environment, by writing and enforcing regulations based on laws passed by Congress.

food scraps
All excess food, including surplus, spoiled, or unsold food such as vegetables and culls (lower quality vegetables or trimmings such as onion peels or carrot tops), as well as plate scrapings. Food scraps also are commonly called food remnants, food residuals, or food waste.

garbage

1. Wasted or spoiled food and other refuse, as from a kitchen or household.
2. A thing that is considered worthless or meaningless.

greenhouse gas (GHG)

A gas that contributes to the greenhouse effect by absorbing infrared radiation, e.g.. carbon dioxide and chlorofluorocarbons.

inorganic waste

Waste material such as sand, salt, iron, calcium, and other mineral materials which are only slightly affected by the action of organisms. Inorganic wastes are chemical substances of mineral origin; whereas organic wastes are chemical substances usually of animal or plant origin.

integrated waste management

The complementary use of a variety of practices to handle solid waste safely and effectively. Techniques include source reduction, recycling, composting, combustion and landfilling.

landfill

A place to dispose of refuse and other waste material by burying it and covering it over with soil, esp. as a method of filling in or extending usable land.

landfill gas

Gas created by the action of micro-organisms within a landfill.

municipal solid waste

Municipal solid waste (MSW), also called urban solid waste, is a waste type that includes predominantly household waste (domestic waste) with sometimes the addition of commercial wastes collected by a municipality within a given area.

organic waste

See biowaste.

recycling

the act of processing used or abandoned materials for use in creating new products.

refuse

Matter thrown away or rejected as worthless; trash.

slag

Stony waste matter separated from metals during the smelting or refining of ore.

source reduction -

Any change in the design, manufacture, purchase, or use of materials or products (including packaging) to reduce their amount or toxicity before they become municipal solid waste.

waste

1. Material that is not wanted; the unusable remains or byproducts of something
2. An act or instance of using or expending something carelessly, extravagantly, or to no purpose.

waste prevention

An activity that prevents waste at its source, which includes reducing the amount of material used and/or the toxicity of the material used to accomplish any task; reuse of a product in its original form; and use of repairable, refillable, or durable products that result in a longer useful life.

waste recovery

The reclamation, collection and separation of materials from the waste stream.

waste stream

The flow or movement of wastes from the point of generation (ie household or commercial premises) to final disposal (ie landfill). A waste stream may reduce significantly over time as valuable items are separated for recycling and are recovered through resource recovery.

waste-to-energy

Waste-to-energy (WtE) or energy-from-waste (EfW) is the process of creating energy in the form of electricity or heat from the incineration of waste source. WtE is a form of energy recovery.

Waste-

an act or instance of using or expending

something carelessly, extravagantly, or to no purpose

Introduction

Since early human civilization people have produced waste. In the early days most human waste, like animal waste, consisted of organic materials and could simply be scattered and left to decompose and return to the soil. Even objects made from nonorganic substances like metals were recycled into new objects or tools. It has only been fairly recently that waste produced by humans has grown to such epic proportions that it has become an environmental and social problem.

The largest fraction of municipal solid waste (MSW) is made up of biodegradable organic materials such as paper products, wood, yard trimmings, and food scraps. In the landfill, organic wastes are broken down by bacteria, a process which results in the release of greenhouse gasses (GHGs). In fact, landfills are largest anthropogenic source of methane, a GHG over twenty times the potency of carbon dioxide, in the United States (US EPA 1996). Organic wastes in landfills have also been linked to the release of other toxic chemicals such as methylated forms of mercury that are created by microbial action (Lindberg 2001). While emissions capture technologies are sometimes used to harvest landfill emissions, recent studies have suggested that gas collection systems are not as efficient at reducing lifetime emissions from landfills than previously thought, and that the new wave of bioreactor landfills[1] may actually magnify the problem (Anderson 2005).

Clearly the management of organic wastes must be altered to improve recovery[2] rates and to improve disposal techniques. Despite being the least recovered organic waste fraction, food scraps could easily be removed from the waste stream and be recovered at the residential scale by composting. However, while residential scale composting would be the most efficient solution, the reality is that many people do not have the means or interest in disposing of their food scraps in this way. Therefore, a method for recovering food scraps at the municipal scale must be implemented.

Some wastewater treatment facilities utilize systems known as constructed wetlands, which are essentially man-made wetlands that are designed to treat wastewater by mimicking the biological relationships found in natural wetland ecosystems. It is possible to adapt this wastewater wetland technology and use constructed wetlands to recover organic material that would otherwise be discarded to the landfill. These wastewater wetlands can be designed to not only treat wastewater, but also to restore damaged wetlands, provide habitat and sanctuary for wildlife, and provide recreational and educational space for people.

[1] Bioreactor landfill - a landfill that rapidly breaks down organic waste by adding liquid and air to enhance microbial action.

[2] Waste recovery - The reclamation, collection, and separation of materials from the waste stream that terminates in a landfill. This could be via recycling, composting, energy recovery, or other forms of reuse.

Part I

A Brief History of Municipal Solid Waste Management

It was not until the Industrial Revolution and mass urbanization that waste production shifted up in scale and waste disposal became a problem. Industrial fabrication has a large number of inputs - petroleum, rubber, plastics, textiles - and this led to a substantial amount of industrial “leftovers” from product manufacturing. Add to this the filth and disease characteristic of massive overcrowding and the result was enormous amounts of waste accumulating in densely populated urban areas. At the turn of the 20th Century, motivated by the fear of epidemics of contagious diseases that were repeatedly overrunning crowded cities, citizen’s groups such as the Ladies Health Protective Association in New York and the Municipal Order League in Chicago pressured cities to establish some form of municipal waste management.

It was this trend of industrialization and urbanization that gave rise to the Municipal Solid Waste Management (MSWM) system in the United States. It became common practice to transport waste outside of populated areas for disposal in landfills that were little more than open pits in the ground. By 1930, MSWM had become an institutionally organized and municipally operated service (Spiegelman 2005).

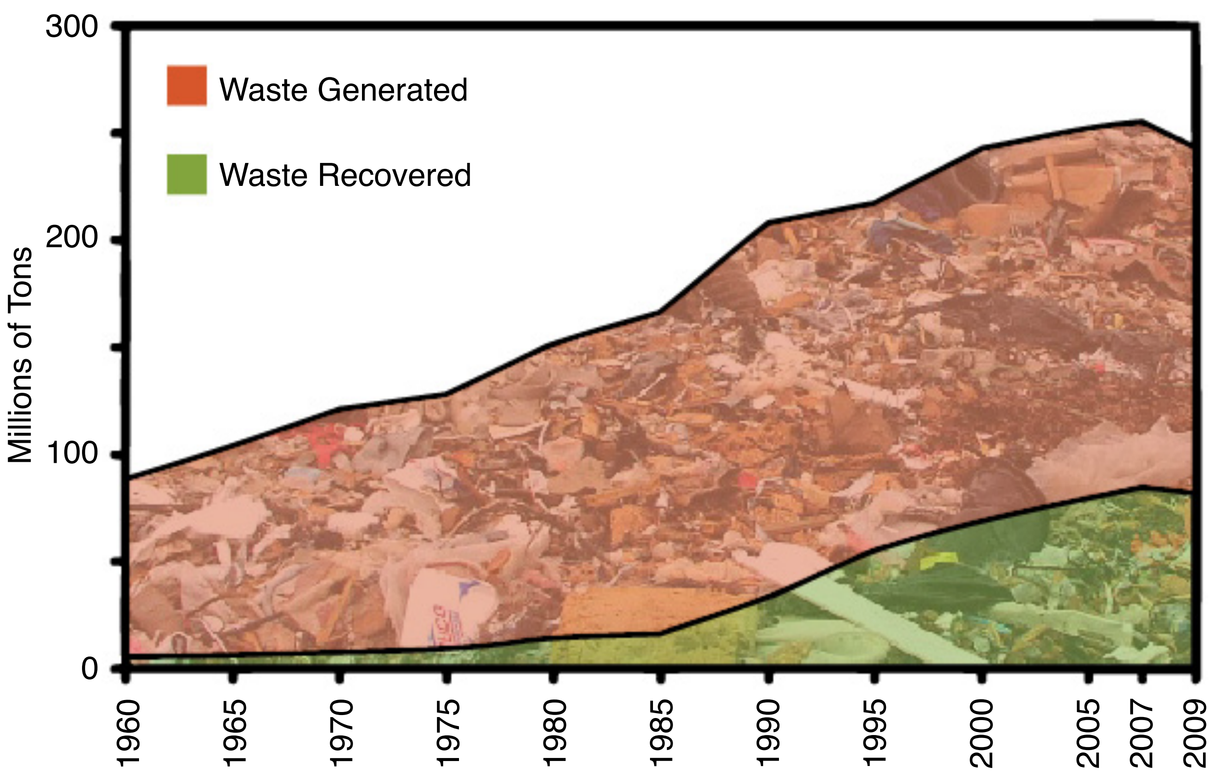
Part II

Waste in the 20th Century

There have been significant changes to the volume and composition of MSW over the course of the 20th Century. A study sample of refuse collected in New York City between 1903 and 1905 found that the annual generation of municipal waste was 1,234 lbs per capita. The study characterized waste into three categories (not including street-sweepings and manure): ashes (mostly coal ash from furnaces, now classified as inorganics), garbage (mostly food scraps, now classified as biowaste), and rubbish (miscellaneous products such as paper, old clothes, etc, now classified as products). Of the study sample, the vast majority was composed of ashes, followed by garbage and finally rubbish. The key changes since that study are a dramatic reduction of inorganic wastes and an equally dramatic rise in product wastes. Inorganic wastes have been reduced largely because of the reclassification of coal ash as industrial waste as opposed to municipal waste. Product wastes, however, have swelled to over ten times the 1905 amount simply due to increased product waste disposal (based on figures from 2001) (Spiegelman 2005).

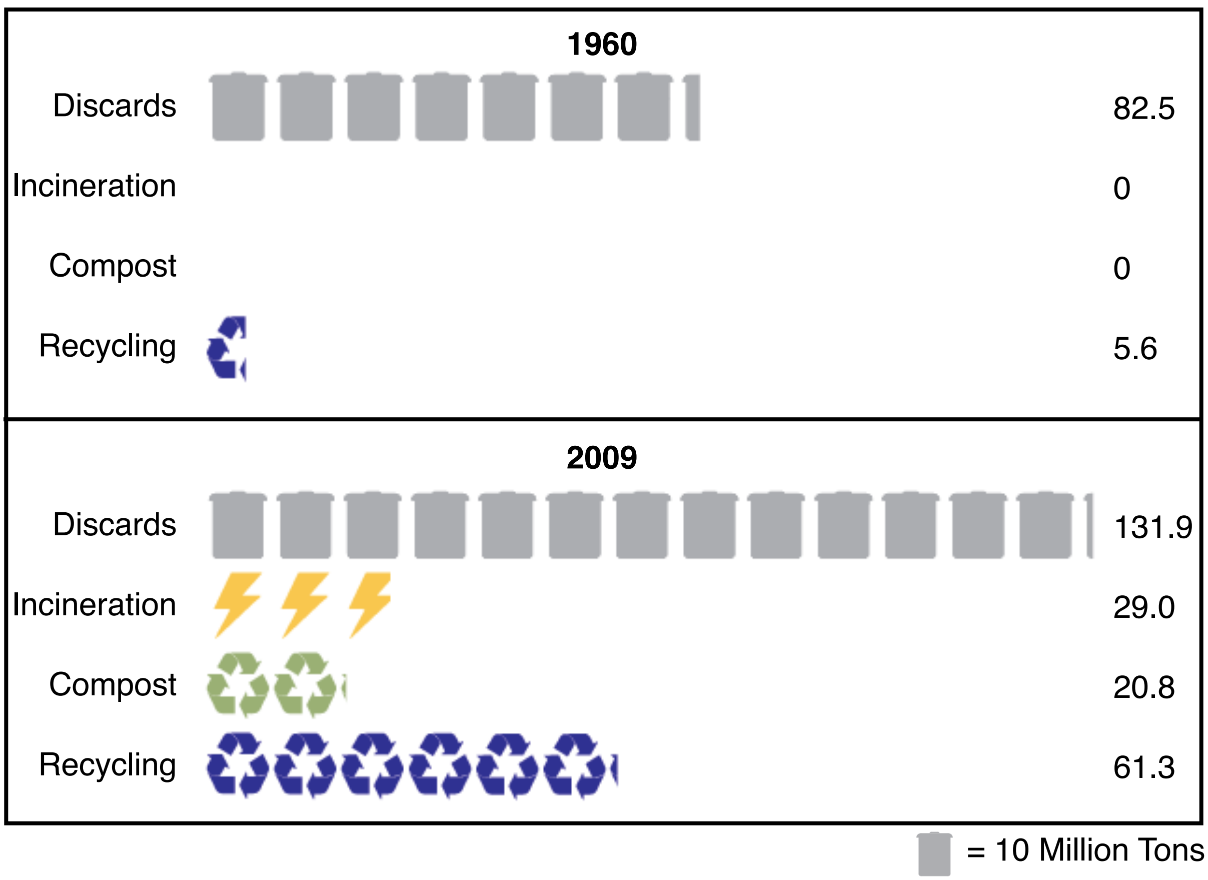
As the 20th Century progressed, more and more products began containing hazardous materials. MSW was commonly discarded to local landfills that were essentially open dumps, and over time these dumps began being used for co-disposal of industrial wastes as well. During the 1960s, 70s, and 80s highly polluted and overflowing landfills began being perceived as a serious environmental and public health issue. As they had done nearly a century earlier, concerned citizens demanded that their government do something about the problem. Local governments across the United States were pressured to decommission local landfills and find or build new ones that met design standards intended to contain contaminants. This era also marked the beginning of a nationwide effort to increase awareness of waste reduction and recycling programs in the United States. In the 1980s local governments began investing in recycling programs that would reduce the flow of MSW to landfills, and all levels of government began campaigning to educate citizens and businesses about waste prevention (Spiegelman 2005).

Figure 2.1: MSW Generated and Recovered Over Time
(US EPA 2010)



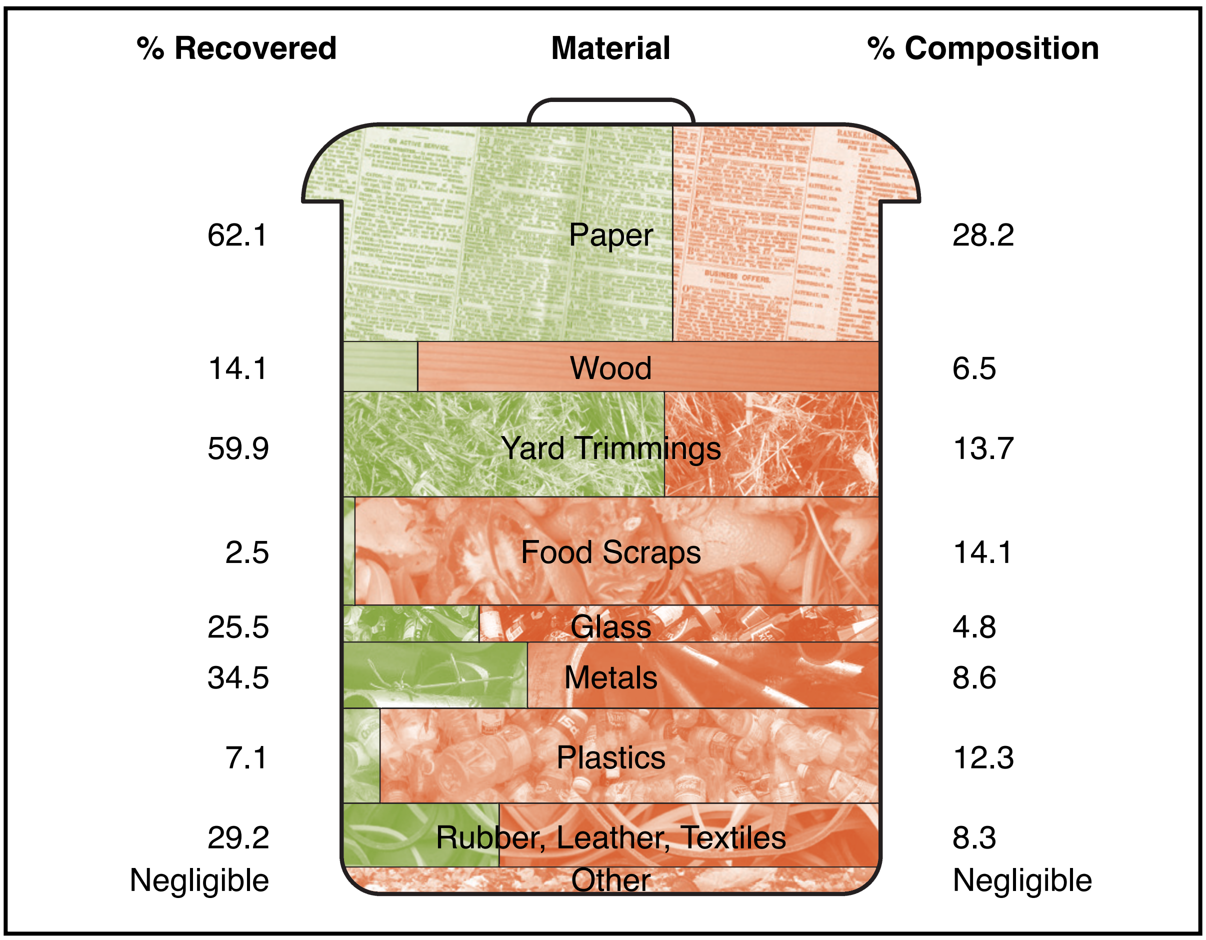
Despite recycling and recovery programs, the MSWM system still buries or burns the majority of waste that enters the waste flow. In 2009, 54.3% of the 243 million tons of MSW was disposed of in landfills and 11.9% was combusted for energy recovery in waste incinerators.

Figure 2.2: MSW Recovery Method (In Millions of Tons)
(US EPA 2009)



While the overall recovery rate for all wastes generated was 33.8%, this figure hides significant differences in the recovery rates of non-product (organic) and product wastes (inorganic) as well as differences between the recovery of different waste fractions within those two categories. The MSWM system is much more effective at recovering some wastes than others. For example, the product waste steel had a recovery rate of 34.5% compared to only 7.1% for plastics. The organic waste paper, the most recovered fraction of MSW, had a recovery rate of 62.1% compared with only a 2.5% recovery rate for food scraps, which did not show any measurable recovery until the 1990s (US EPA 2010).

Figure 2.3: Total 2009 MSW Generation and Recovery by Composition
(243 Million Tons Before Recycling) (US EPA 2010)



Part III

The Limitations of MSWM

According to the United States Environmental Protection Agency (US EPA), per-capita waste generation has nearly doubled since 1960 from 2.7 to 4.41 lbs/day (US EPA 2009). While product waste generation continues to grow, the growth of product waste recycling has essentially stalled out. One theory for this phenomenon is that the MSWM system has inbred limitations in managing product wastes; the key practices of the EPA's integrated waste management strategy - source reduction, recovery for recycling, and environmentally safe disposal - are either wholly or partially beyond the control of the MSWM system (source reduction and design for recycling/disposal, respectively) (Spiegelman 2005). Simply put, source reduction occurs at the producer level which is outside the scope of the MSWM system, and since producers are not held accountable for product wastes, they have no incentive to make products more readily recyclable or recoverable.

A possible solution to this scenario would be to extend the responsibilities of managing product wastes to the producers and to the production and consumption system, therefore making the costs or savings associated with product waste disposal and recycling directly connected to producers. Product manufacturers would then be incentivized to design for recycling, waste prevention, and safe disposal. Such systems, known as Extended Producer Responsibility (EPR) systems, are already in place in some countries around the world. In much of Europe, for example, electronics manufacturers are charged with the recycling and environmentally sound disposal of their products, and they in turn pass that cost on to the consumer as an expected tax on goods (Loux 2011).

In contrast, what has happened in the United States is that the MSWM system has effectively enabled an economy of “disposable” products whose disposability is not provided by producers and the production and consumption system, but rather by the MSWM system and at public (and environmental) expense. The only way to truly solve this problem is to eliminate waste from the source, a method known as source reduction. The US EPA defines waste prevention as:

> *“any change in the design, manufacturing, purchase, or use of materials or products (including packaging) to reduce their amount or toxicity before they become solid waste. …Thus source reduction activities often affect the waste stream before the point of generation.”*
>
> (US EPA 2003)

Municipal solid waste reduction is attainable, but source reduction of product wastes would require a restructuring of the entire producer and consumer system, not to mention a significant shift in economic and social norms. Such a shift is more a policy issue than a design issue and so for the sake of this study, product wastes will be overlooked. That being said, it is important to note that some small-scale source reduction is possible through policy at the municipal scale. For example, Santa Cruz, CA has outlawed styrofoam containers such as those used for take out containers from restaurants. Other cities have similarly banned non-recyclable disposable items like plastic shopping bags (City of Santa Cruz 1998). While these efforts are hardly measurable at a grand scale, they do make a tangible reduction in what are usually un-recyclable municipal solid wastes.

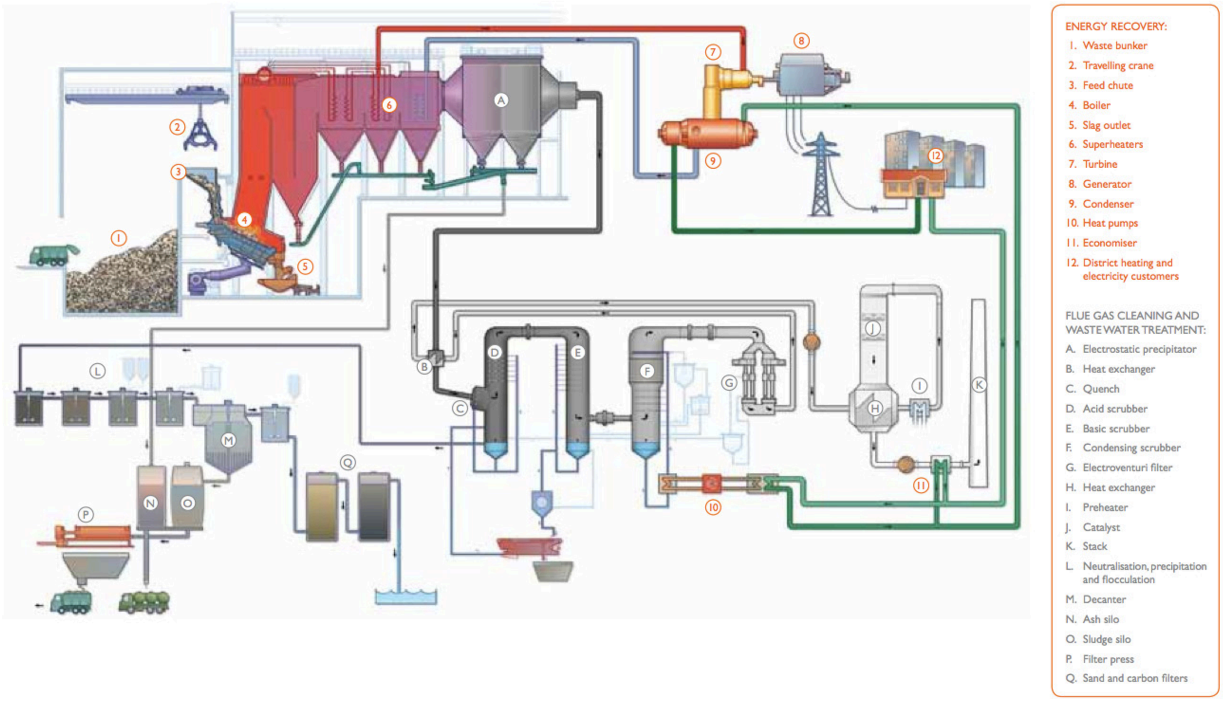
Part IV

Examples of MSWM Technology

While the source reduction of MSW may not be a reality, this does not mean that all unrecycled wastes end up in the landfill. A small yet growing percentage of MSW is being recovered via energy recovery systems known as waste-to-energy (WtE) or energy-from-waste (EfW). WtE is the process of creating energy in the form of electricity or heat from the incineration of waste.

The SYSAV waste-to-energy plant in Malmo, Sweden is an excellent example of such an integrated WtE system. Of all the waste that comes to SYSAV, only 4% ends up in a landfill. The plant receives about 550,000 tons of waste from the city each year, and that waste is incinerated in a process that produces 1.4 million MWh/year, enough electricity to power 70,000 local homes while also powering the various processes of the plant itself. At the same time, the heat generated from the incineration process is used in a district-heating network that serves the city. About 15-20% of the waste by weight is left over after incineration in the form of slag. This slag is recycled as much as possible: about 90% is reused as slag gravel, a viable aggregate material for construction, and other valuable materials such as metals are removed for reuse. Only then is the remaining hazardous or non-recyclable waste sent to the landfill or to special treatment facilities (SYSAV 2011).

Figure 4.1: SYSAV WtE Plant Process Section
(SYSAV)



Food wastes from residential and commercial sources are also collected and reused as biogas or biofertilizer. The biogas produced is mostly made up of methane, so it can be distributed in the same preexisting network as natural gas, and when combusted it produces fewer harmful emissions than fossil fuels. The end residue from the biogas process is sent to the waste-to-energy plant for incineration. A similar facility exists in Stockholm where wastewater is used to generate biofuel for the city's public bus fleet. SYSAV also deals with Malmo's recyclable materials, which are collected and sorted into fractions, 90% of which can be recycled as materials or energy at the waste-to-energy plant. Only the remaining 10% of the material goes to the landfill (SYSAV 2011).

Figure 4.2: SYSAV Waste Recovery Site
(SYSAV)

However, while such a system is a clever way to eliminate existing solid waste, there is ample evidence that suggests that from a full systems perspective recycling saves far more energy than that gained during incineration with energy recovery or that captured from landfill gas (Spiegelman 2005). In particular, organic wastes can be managed through composting and other controlled technologies.

Biowaste Separation

While the MSWM system is relatively successful at recovering some fractions of waste, such as paper products and yard trimmings, over 97% of food scraps in the United States go unrecovered and eventually find their way to the landfill (US EPA 2011). The irony of this situation is that food scraps are the easiest fraction of MSW to recover, as such materials could easily be composted at the residential scale. However the challenge is convincing people to change their habits and to put in the time and effort to compost at home. Clearly it is not feasible to expect most, or

Figure 5.1: Total 2009 Biowaste by Composition
(151.76 Mil. Tons Before Recovery) (US EPA 2010)

Material	**% Composition**
Paper	45.1
Wood	22.6
Yard Trimmings	10.4
Food Scraps	21.9

even many, people to alter their usual behaviors when it is so easy to simply throw food waste away in the garbage can with everything else. Therefore any meaningful recovery of organic wastes at the municipal level must begin with separation of these wastes from the inorganic wastes at the source, i.e. at the home.

In order to adequately recover organic wastes, organic material must be separated from inorganic material. Separation at the source is the most efficient way to separate organic waste into its own waste stream. For this to be successful, collection should start at the residential level. It has been shown that providing convenient and sanitary receptacles for the collection of kitchen waste is a successful way to ensure that food scraps do not become discarded with nonorganic trash. To that end, small counter-top receptacles or any such collection containers provided by the municipality should be used to collect kitchen waste.

Some municipalities are doing this already; the Contra Costa County Solid Waste Authority (CCCSWA) in California asked residents to vote on a food scraps collection container and then provided the chosen container to all residents of the county. Food scraps are discarded into the containers which may be conveniently placed in the kitchen or elsewhere at the user's preference. When the container is

Figure 5.2: Norseman Source Separation Organics Kitchen Container

This counter-top food waste container is made out of BPA-free plastics and is designed to seal completely to lock in odors.

(Norseman Environmental Products)

full its contents are emptied into green waste bins already used for yard trimmings and put out for typical curb-side collection. Now separated into their own isolated waste flow, organic wastes may be easily collected by existing MSW collection infrastructure.

Part VI

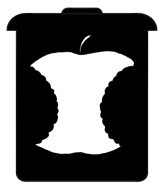
Biowaste Collection

A notable obstacle in implementing a new system that relies on people altering their normal activity is securing participation from the public. Any effort to recover organic wastes will fail if the public rejects the new system and continues to combine organic and inorganic wastes as they have always done. To that end, a two pronged campaign of incentives-based collection and education is the key to the successful adoption of the new system.

Incentives for recycling are nothing new; the California Redemption Value (CRV), enacted in 1987, is a tax attached to certain recyclable beverage containers such as aluminum cans, plastic bottles, and glass bottles (CA.gov 2011). The consumer may redeem the CRV by bringing containers to recycling centers or back to some stores. Similar systems are already in place in some cities for the recycling of MSW at the municipal scale. In these systems, recycling bins are tagged with a unique barcode or serial number that is registered to an address. As collection trucks make their rounds, they scan and weigh recycling containers and credit the homeowner's account based on the how much was recycled. The credits translate into coupons for local businesses, a refund for municipal services, or even a cash value. Such a system could easily be adapted to the collection of organic wastes and would incentivize people to ensure that their organic waste is properly sorted out of the main waste stream.

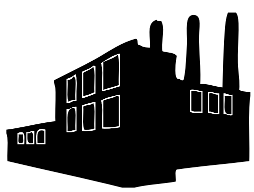
Figure 6.1: Organic Waste Stream Collection Process Section

This section depicts the process of biowaste collection starting with residential scale collection (Phase 1). Now in an isolated waste stream, the organic waste is collected by waste collection trucks (Phase 2) and brought to a primary treatment facility (Phase 3).



Phase 1:
Organic Waste Separation

Phase 2:
Organic Waste Collection



Phase 3:
Consolidation at Primary Treatment Facility

It is important to combine any efforts to alter the existing waste collection system with a campaign to educated the public about how and why these changes are taking place. Information should be distributed by the municipality that provides a description of how the new system will function, when it will come into play, and where residents may go for more information or assistance. This double sided approach would make the new system transparent and understandable, with clear benefits for those who participate.

Part VII

Wetland Siting and Design

Proper location and design of the constructed wetland is essential to its success as a functional treatment system and as a functional ecosystem. Special care must be taken in considering the individual factors of each and every constructed wetland project; there is no “cookie-cutter” template that can simply be stamped onto any and every site. The Interagency Work Group on Constructed Wetlands (IWGCW) is a multi-institutional organization composed of the US EPA, US Army Corps of Engineers, US Fish and Wildlife Service, Natural Resources Conservation Service, National Marine Fisheries Service, and US Bureau of Reclamation. This organization offers guiding principles for planning, siting, design, construction, operation, maintenance, and monitoring of constructed treatment wetlands, as well as information on current Agency policies, permits, regulations, and resources. While the guide was written with wastewater treatment in mind, its principles are still applicable to wetlands meant to recover organic municipal solid waste.

The Guiding Principles are intended to:

- Provide a framework for promoting sustainable, environmentally safe constructed treatment wetland projects.
- Be usable nationally under a variety of settings and circumstances.

- Educate and inform public and private decision makers, Federal, State,Tribal and Local regulatory and resource agency personnel, and the general public.
- Provide guidance for environmental performance, especially for projects which are intended to provide water reuse, wildlife habitat, and public use, in addition to other possible objectives.
- Highlight opportunities to restore and create wetlands.
- Be applied, when appropriate, to any effluent or other source water treatment system as long as the source is adequately treated to meet applicable standards, protects the existing beneficial uses, and does not degrade the receiving waters.
- Create opportunities for beneficial uses of dredged material, if feasible.
- Minimize risks from contamination, toxicity, and vector-borne disease.
- Be applied in a watershed context.
- Be flexible enough to accommodate regional differences in climate, hydrogeomorphology, wildlife habitat needs, etc.
- Complement Federal, Regional, State,Tribal, or Local authority, rules, and regulations and policies.

(IWCGW 2000)

Guidelines for Siting Constructed Wetlands:

Constructed treatment wetlands should generally be sited on uplands and outside floodplains or floodways in order to avoid damage to natural wetlands and other aquatic resources. However, it is sometimes possible use a constructed wetland to restore damaged natural wetland systems. This is appropriate if the source water meets all applicable water quality standards and criteria, its use would result in a net environmental benefit to the aquatic system's natural functions and values, and it would help restore the aquatic system to its historic natural condition. Prime candidates for restoration may include wetlands that were degraded or destroyed through the diversion of water supplies. (IWCGW 2000)

When siting a constructed treatment wetland, its role within the watershed as well as within the broader ecosystem of the region must be considered. This includes potential water quality impacts (physical, chemical, biological, thermal) to surface waters and groundwater, surrounding and upstream land uses, location of the wetland in relation to wildlife corridors or flyways, potential threats from the introduction of non-native plant or animal species, and local citizens' perception of the appropriateness of constructed treatment wetlands in their watershed. (IWCGW 2000)

The suitability of a site will be contingent on a number of environmental features, such as: substrate, soil chemistry, hydrology/geomorphology, vegetation, presence of endangered species or critical habitat, wildlife. It will also be contingent on a number of social features such as: cultural/socioeconomic impacts including environmental justice issues, the surrounding landscape, landuse and zoning considerations, and potential impacts to safety and health such as impacts from major flooding events and vector-borne disease. All of these factors must be carefully considered in determining the site location. (IWCGW 2000)

Guidelines for Designing Constructed Wetlands:

Constructed wetlands should be designed to avoid any disruption of plant and animal communities, any alteration of the existing hydrologic features of natural wetlands or adjacent surface water bodies, any introduction or spread of noxious species, any threats to fish and wildlife from toxins and/or pathogens, and any degradation of downstream water quality and groundwater sources. To that end, rectangular basins, rigid structures, and straight channels should be avoided whenever possible. Mimicking natural landscape features and using slopes, grades, and gravity to achieve passive flow is key to a low maintenance design. The wetland should also be surrounded by a transitional zone such as a woody vegetative buffer to avoid unnatural landscape transitions and to provide wildlife corridor space. (IWCGW 2000)

It may be necessary to incorporate vector controls such as native mosquito-eating fish and birds. However, special care should be taken to avoid the introduction of destructive or invasive non-native wildlife. In some cases, excessive use of wetlands by wildlife can result in wildlife stress and disease problems, degradation of water quality due to high loadings of nutrients, solids, and fecal coliform, and erosion resulting from loss of vegetation due to over-grazing and trampling. (IWCGW 2000)

The constructed treatment wetland should be designed to be successful on an environmental level and a social/political level. The public's perception of the project and its effects on neighboring residents and adjacent land uses must be considered. Concerns like drinking water contamination, unpleasant odors, mosquitos, accidental access by small children, and other safety and health issues should be addressed. Community involvement from early in the process will help ensure public support and approval while developing a safe project for everyone to enjoy. When appropriate, encouraging public access and working with local educators or schools to design informative and educational displays to install at the site will help foster acceptance and appreciation for the wetland. (IWCGW 2000)

Part VIII

Wetland Recovery

After collection, the organic wastes are consolidated in a central location for recovery. Before the waste can be released into the wetland, it must first undergo a primary treatment phase to ensure that no hazardous or inorganic materials were introduced into the organic waste stream. This primary treatment phase may take a variety of forms based on the makeup of the organic wastes being recovered, but it would almost certainly include an initial screening process to remove unwanted substances and a homogenization process that would pulverize large particles to ensure a uniform consistency. The organic waste would then be dissolved into water and released into the wetland as primary effluent (US EPA 2000).

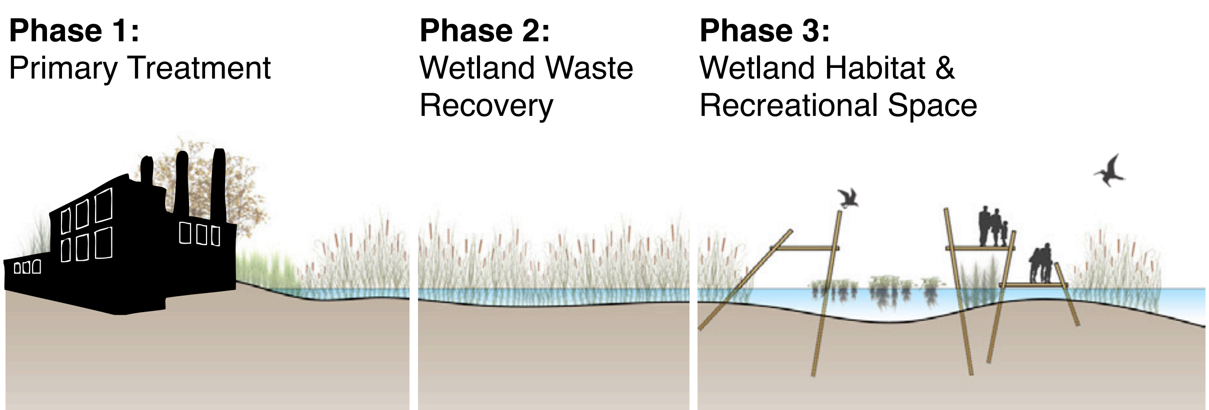
It is important to note that the waste stream may be tapped at various points along the treatment process to extract resources or products before terminating in the wetland. For example, appropriate organic wastes may be separated from the overall organic waste stream and used for municipal composting programs. The compost can then be sold or distributed to to residents of the municipality. Another option is to add oxygen and place the slurry in a chamber where accelerated microbial decomposition will take place. GHG emissions can be captured from the chamber to be sold or reused and the end product of fertilizer can be reused in the landscape.

After primary treatment and any initial separation of the waste for recovery, the primary effluent is released into the wetland where secondary treatment takes place. The dissolved biodegradable material is removed from the water by microorganisms which live on the surfaces of aquatic plants and soils. Decomposers such as bacteria, fungi, and actinomycetes, present in any wetland, actively break down this dissolved and particulate organic material into carbon dioxide and water (US EPA 2000). The carbon dioxide is absorbed on-site by wetland flora leaving a secondary effluent of primarily water. The secondary effluent may be considered the final discharge and left to integrate into the wetland habitat, or it can be disinfected in tertiary treatment and reused for agriculture, landscape applications, or even sent to purification facilities and used as drinking water.

Figure 8.1: Wetland Waste Recovery Process Section

This section depicts the process of biowaste recovery in the constructed wetland. After primary treatment (Phase 1), the organic waste is dissolved into water and released into the wetland where it is biodegraded by microbial action (Phase 2). The secondary effluent is mostly water and becomes integrated into the wetland habitat (Phase 3)

(Fortney 2010)



Even if no tangible products are recovered from the organic waste stream, the wetland can be a “product” in and of itself. Wetlands, even constructed ones, are focal points of biodiversity and provide habitat for plants and animals that can not survive elsewhere. Such a place can also be used as recreational space and as an outdoor classroom for the community.

Conclusion

As the global population continues to rise and industries continue to grow, municipal solid waste production will also rise. The day may soon come when there is simply no more room to excavate another landfill. Short of source reduction, the options for reducing MSW are limited to extensive waste reuse, recycling, and recovery. However, even the best programs today barely exceed 50% materials recycling or recovery. Looking forward, it is imperative that the MSWM system embrace sustainable means of waste recovery and perhaps someday in the future, the culture of disposability will finally be rejected and left where it belongs- in the trash.

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