LEARNING MADE EASY

NWRA & EREF Special Edition

Waste & Recycling

for dummies®
A Wiley Brand

How recycling works

How composting, landfilling, and waste-to-energy work

What happens to waste

Brought to you by

EREF

Faithe Wempen

Dear reader,

We're excited that you're interested in learning more about the wonderful world of waste and recycling! You may already have a basic understanding (or some assumptions) about the industry, but this book will provide you with a clearer picture of how the entire industry works.

The waste and recycling industry has been around for a long time, since the dawn of civilization. Hundreds of years ago, it used to be simply throwing things in piles. But as modern society has become more complex, managing waste and recycling today has also gotten more complex, which you will discover as you turn the pages of *Waste & Recycling For Dummies*.

In this book, you will learn the importance of the industry and how managing waste properly can help protect human health and the environment. Without proper waste management, our air, land, and water can become polluted, and our climate can change for the worse. Recycling helps preserve our natural resources for future generations.

As leaders in the industry, we at the National Waste & Recycling Association (NWRA) and the Environmental Research & Education Foundation (EREF) strive to provide valuable resources and support to those in the industry. From advocacy, to safety, to research, to education, we serve as the voice of the industry and help to provide a clearer understanding of the sector's ongoing efforts to keep the environment clean and safe.

As you dive into this book, we encourage you to take a look at your own actions and see what you can do to leave the world in a better place than you found it.

Happy reading!

Darrell Smith, Ph.D.
President and CEO
National Waste & Recycling Association

Bryan Staley, Ph.D., P.E.
President and CEO
Environmental Research & Education Foundation

Waste & Recycling

NWRA & EREF Special Edition

by Faithe Wempen

for dummies®
A Wiley Brand

Waste & Recycling For Dummies®, NWRA & EREF Special Edition

Published by
John Wiley & Sons, Inc.
111 River St.
Hoboken, NJ 07030-5774
www.wiley.com

ISBN 978-1-119- 74859-5 (pbk); ISBN 978-1-119-74858-8 (ebk)

Manufactured in the United States of America

10 9 8 7 6 5 4 3 2 1

Publisher's Acknowledgments

Some of the people who helped bring this book to market include the following:

Project Editor: Jennifer Bingham
Acquisitions Editor: Ashley Coffey
Editorial Manager: Rev Mengle
Business Development Representative: Molly Daugherty
Production Editor: Siddique Shaik

Introduction

Each week, millions of Americans drag a full trash bin out to the curb in the morning, and by the end of the day, it's empty. Because it quickly gets out of sight, it tends to get out of our mind. Most people don't give a lot of thought to how critical waste management is to our modern society.

There's a lot more involved in waste collection and disposal than meets the eye. And if you knew how it all actually works, you might be impressed at how well the systems are engineered.

If you knew more about the system, you would also understand how the choices you make can dramatically help both your waste collection provider and the environment — or dramatically hurt them. You might even start paying more attention to which bin your waste goes into once you see what a big difference it can make.

If at this point you're at least a little curious, you're in the right place. *Waste & Recycling For Dummies* provides an interesting, easy-to-read overview of the entire waste management system, from curbside collection through the waste's ultimate disposal. It's written for the average citizen who wants to know more about how our trash simply "goes away" and how it's managed. No previous knowledge or experience is required. Prepare to have your eyes opened and your perspective changed!

Icons Used in This Book

To make it easy to navigate to the most useful information, these icons highlight key text:

TIP

Follow the lightbulb for tips that can save you time and effort.

WARNING

Watch out for these potential pitfalls on the road ahead.

REMEMBER

Take careful note of these key takeaway points.

TECHNICAL STUFF

Read these optional passages if you crave a more technical explanation.

Where to Go Next

Besides this book, there are lots of fun and educational apps, games, and online resources that can help kickstart conversations about the wonderful world of waste. Dig in to expand your knowledge of waste and recycling, and share the information with friends and family.

Here are some places to start:

- https://wasterecycling.org
- https://erefdn.org
- https://www.epa.gov/recycle/reduce-reuse-recycle-resources-students-and-educators
- https://www.usda.gov/foodlossandwaste
- https://kids.nationalgeographic.com/games/action-and-adventure/recycle-roundup-new/
- https://earth911.com/irecycle

IN THIS CHAPTER

- Building your waste and recycling vocabulary
- Recognizing why waste management is important
- Ranking the waste management methods

Chapter 1
Understanding Waste and Recycling

Think about everything you discard in a year — food scraps, plastic packaging, broken lawn chairs, old magazines, and so on. How many pounds do you think it all adds up to? One hundred? Two hundred?

Nope, not even close. According to the United States Environmental Protection Agency (EPA), the average person in the U.S. generates 1,600 pounds of municipal solid waste a year. If you live to be age 75, you will have generated *more than 61 tons* of waste in your lifetime. Some estimates are even higher; the Environmental Research & Education Foundation (EREF) estimates 2,190 pounds per person per year, or 82 tons in a lifetime.

Waste doesn't just go away on its own. It needs some help to ensure it's managed efficiently and safely, and, ideally, returns a benefit back to society. *Waste management* refers to the process of helping waste disappear, by turning it into new products through recycling; converting it to some other form, like compost or energy; or putting it in a repository where it can be stored for longer periods of time, like landfilling. In this chapter, you'll learn the key components of waste management and find out why it's so important.

Learning the Lingo

This section defines some terms. Some of them may seem pretty basic, but they're misunderstood and misused more often than you might think.

REMEMBER

Simply put, *solid waste* is solid or semisolid material that's no longer wanted by its owner and is discarded or abandoned.

A subset of that is *municipal solid waste (MSW)*, which is solid waste discarded by the public, retail businesses, or offices (as opposed to, say, a manufacturing facility). This means MSW includes the waste you put out on the curb each week. MSW has many aliases, including garbage, trash, rubbish, and junk. It consists mainly of paper, food, yard trimmings, and plastics, with smaller amounts of other materials filling out the balance. Figure 1-1 shows the breakdown according to 2017 EPA data.

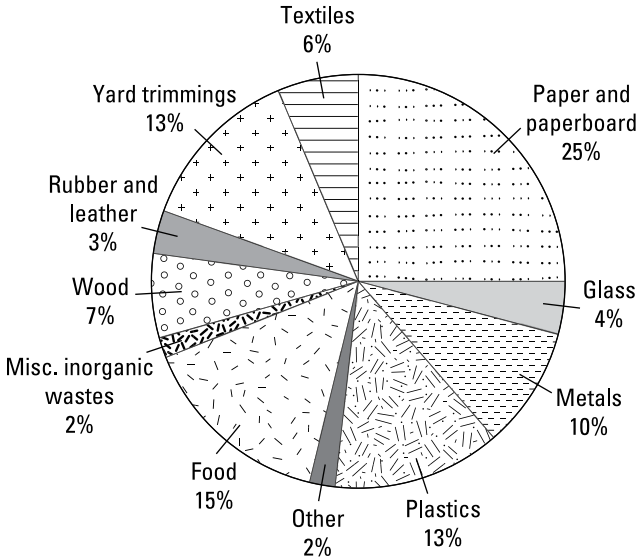

FIGURE 1-1: What's in MSW?

Some people also use the term *litter* to refer to MSW, but it actually has a very different meaning. While litter is part of MSW, it's the *un*managed portion of waste. For example, a candy wrapper isn't necessarily litter — it's just waste. If you throw it on the ground, instead of putting it in a trash bin, it becomes litter. Litter

is the opposite of waste management. Managing waste ensures it will be handled in a way that protects both human health and the environment.

This book focuses mainly on MSW, but there are many other kinds of waste, such as medical waste, industrial waste, wastewater sludge, oil and gas waste, waste generated by agriculture and mining, and construction and demolition debris.

REMEMBER

Waste management is the process of collecting and disposing of waste. It can include the following:

- **Collection:** Gathering waste, such as with a curbside collection service.
- **Disposal:** Putting waste somewhere it can be safely stored for a long time, such as in a landfill or processing it at a waste-to-energy facility.
- **Composting:** Processing organic waste, such as food scraps and yard trimmings, in a way that speeds up its decomposition and provides a product that can be used to enhance soil.
- **Recycling:** Reusing material to make new items, like making new aluminum cans from old ones.
- **Waste-to-energy:** Using waste to generate energy, such as heat or electricity, by either burning it or heating water to generate steam.
- **Landfill:** An engineered system of burying waste that protects the environment. Energy may also be produced from decomposing waste.

You'll learn more about these topics in upcoming chapters.

Why Waste Management Matters

You've probably heard people talk about "saving the planet" or being "sustainable." What you may not know is effective waste management can help accomplish these lofty goals. Waste management has a big impact on the Earth's environmental health and well-being. Unmanaged or poorly managed waste can pollute air, land, and water, and even contribute to climate change. We owe it to future generations to leave the world in a better place than we found it.

In reality, we manage waste for a far less altruistic reason: because it's in our best interest. Managing waste is a core infrastructure need for society, just like power, transportation, and clean water. Nobody wants to live in a place where garbage is piled up in the streets, water is polluted, and vermin are everywhere. That's what happens when a society doesn't stay on top of its waste management.

WARNING

Improper or inadequate waste management can also affect personal health. Air, water, and soil contamination can lead to illness and even death. Unmanaged waste can attract rats and insects, which are unpleasant to be around and can spread diseases. Polluted water and air affect people's health, especially children, elderly, and people with autoimmune or breathing problems.

Most people don't realize how fragile our waste management system is, and how quickly it can be disrupted. In New York City in 1968, sanitation workers went on strike for nine days, and the result was a sea of garbage. On day three of the strike, with 30,000 tons of trash on the streets, the *New York Times* reported the city looked like "a vast slum as mounds of refuse grow higher and strong winds whirl the filth through the streets." The uncollected trash grew to 100,000 tons by the end of the strike, with waist-high piles of mostly organic waste along the sidewalks.

Ranking the Waste Management Methods

It's not possible to completely eliminate waste, but the goal is to minimize the effect waste has on people's lives and the planet. So, how can we find ways to make waste as small a problem as possible?

There are many ways to manage waste, but they're not all equally beneficial. Figure 1-2 provides the typical solid waste hierarchy, which is a simplified arrangement of waste management options, from most to least preferable.

WARNING

While the hierarchy is a simplified general rule of thumb, just like grammar rules, there are exceptions. Remember "I before E except after C and except for a long list of exceptions?" Waste management is no different. Compost may be a more desirable

waste management option than landfilling, but if it has to travel 500 miles, then it's not. Similarly, contaminated compost may make landfilling the preferred option. Things are always a little more complex when looking at the details. For example, EPA accounts for some of these factors in its Waste Reduction Model, which shows impacts from various waste management strategies depending on different factors such as distance traveled.

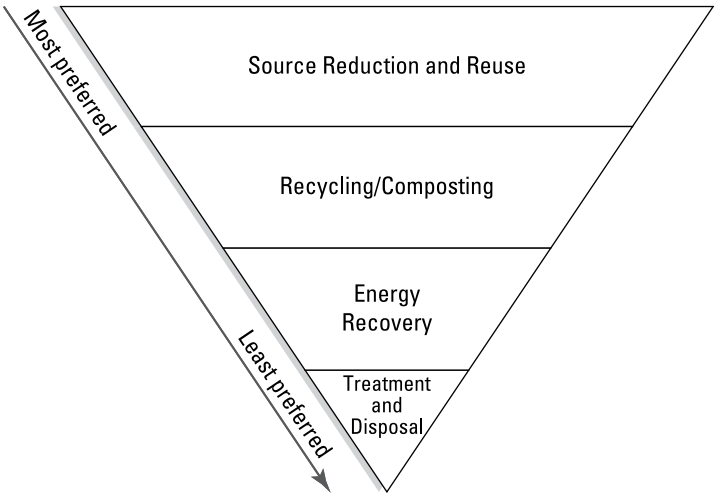

FIGURE 1-2: Solid Waste Hierarchy.

Source reduction and reuse

The best waste management technique is to avoid generating waste in the first place. After all, you don't have to worry about how to dispose of trash that never existed.


TIP

As individuals, we can find ways to prevent waste from entering the system, such as composting our food waste and landscaping our property in ways that generate less yard waste. For example, instead of bagging grass clippings, you can set your lawn mower to mulch the clippings as it cuts, and leave them on the lawn to decompose. (That's called *grasscycling*.) Buying products that last longer also leads to less waste.

Manufacturers and retailers can reduce the amount of waste they generate — and save money — by looking at the way they acquire materials, make products, package them, ship them, and sell them. For example, an automotive company might practice

lightweighting, which means redesigning vehicles to be lighter weight. Lighter vehicles require less material to build, and there is less waste when they're discarded. Product makers might also find ways to reduce the amount of waste generated during manufacturing. Lightweighting has also been applied to packaging, which is why material now comes in plastic bottles and pouches opposed to glass.

Manufacturers can help consumers generate less waste by using less packaging. They can also use packaging materials that have value through recycling or energy conversion after use. A classic example is the packaging of CDs and DVDs. Decades ago, it was common for CDs and DVDs to be heavily packaged, with a plastic case inside a larger cardboard sleeve or box. A few years back, packaging changed, so most were sold in plastic storage cases with just the shrink wrapped plastic as the disposable packaging. Today, music and video are more often streamed online or downloaded, eliminating the packaging and the physical product entirely.

Reusing what you already have also makes a big difference. Think about everything you throw away weekly: plastic bags, used paper towels, tissues, and so on. Then consider what reusable materials you could replace them with, like tote bags, cloth towels, and handkerchiefs. Reuse can be a double bonus, because it prevents items from entering the waste system and reduces demand for replacement products.

Manufacturers and retailers can also make an impact with reuse. For example, suppose a business receives raw materials stacked on wood pallets. Reusing these pallets when shipping the manufactured products to its customers prevents the pallets from becoming waste (yet), and saves money. Some businesses also find ways to reuse wastewater and other material streams from their manufacturing in other processes.

Recycling and composting

If you can't avoid creating waste in the first place, what then? A useful management option is to make waste into new products through recycling or composting. Studies by EREF and EPA suggest recycling and composting account for approximately 27 to 35 percent of MSW management in the U.S., respectively.

Recycling uses waste material to make something new. That's different from reuse, which repurposes the old thing without

changing its form. For example, if you refill a water bottle, that's reuse. But if you shred the water bottle and melt down the pieces to make a new water bottle, that's recycling.

REMEMBER

Recycling makes good sense for many reasons, one of which is materials can be made into new products, multiplying the potential number of times that material is used. Another is it reduces the need for new primary materials to be extracted or grown to make products, which preserves these resources for future generations. The recycling industry also contributes to the economy by providing jobs.

Composting is the process of breaking down organic matter so it goes back to its natural form. *Organics* are materials from formerly living plants or animals. Composting combines organic waste with water, minerals, microbes, and air to transform it into heat, water vapor, carbon dioxide, minerals, and nutrient dense soil amendment.

Energy recovery

Waste that isn't recycled or composted must be disposed of in some way. Energy recovery is about getting benefit out of the disposal process.

TECHNICAL STUFF

The most common type of energy recovery is to combust (burn) waste and capture energy this generates. This captured heat can be used in industrial processes and electricity generation as a substitute for burning other fuel. In the U.S., there are 75 facilities for MSW combustion, and together, they produce 2,725 megawatts of power annually by burning 29 million tons of MSW.

WHY ARE EPA AND EREF STATISTICS DIFFERENT?

EPA's numbers are based on the "front end." It estimates waste based on the volume of goods manufactured and assumes how long a person will hold onto goods before they are discarded.

EREF's numbers are based on the "back end." It represents how much waste was directly handled by landfills, composting operations, recycling facilities, and waste-to-energy facilities.

Additionally, combusting waste reduces its volume by about 87 percent. Some of the ash can then be used in cement and concrete, road pavement, glass, and ceramics.

Another energy recovery method is to use gas created from waste through gasification, anaerobic digestion, or landfills outfitted with landfill gas-to-energy systems, which convert gas generated from waste and then capture that gas to use for energy or heat.

Treatment and disposal

Even after all the various steps are taken to avoid, convert, and reduce waste, a portion still remains. Some of that is because of the nature of the waste itself — not everything can be recycled, composted, or turned into energy. Other times it's because waste that could be recycled or composted is put in the wrong bin. A lot of it is because there's no value or benefit via recycling or composting, or a material may be contaminated. For example, material contaminated with food can't be recycled in most cases. Therefore, the remaining waste usually goes to a landfill. It's estimated that between 62 to 64 percent of MSW generated goes to landfills.

When many people hear the word *landfill,* they immediately think the worst: An open dump with litter and vermin everywhere, stinking up the area for miles. Modern landfills are much more sophisticated than that. Today's landfills are well engineered to store waste while safely managing gas generated from the organic portion of MSW, and often turn it into energy, as you will learn later in the book.

The Three Rs

One of the easiest to understand models for making decisions related to waste management is *the three Rs* (reduce, reuse, recycle). Remembering these three concepts can help people and companies generate less waste and provide benefits when waste is generated.

WARNING

Keep in mind, though, that not all items are recyclable. So, you need to recycle the right items and not just place anything and everything in a recycling bin, which can be worse for the environment than putting a nonrecyclable item in a landfill bin.

Reducing waste

Waste management isn't free. There are consequences whenever you throw anything away, especially if you do so improperly. Beyond the financial cost of waste management, other consequences include having fewer resources available and polluting the environment around you.

Most people, if they keep the "price tag" of waste in mind, want to minimize or avoid negative consequences. People have found thousands of creative ways to reduce the amount of waste they generate, with entire websites devoted to sharing best practices. Here are a few ideas to get you started:

- Reduce the amount of paper mail you receive by removing yourself from advertisers' mailing lists.
- Think before you buy.
- Read e-books, check books out of your local library, or buy used books.
- Choose washable, reusable products over disposable ones when possible.
- Borrow or rent items that you don't use often.
- Buy from local stores rather than online, which requires packaging and shipping.
- Buy products with minimal packaging.
- Buy in bulk, and refill dispensers.

Increasing reuse

Every time you reuse something rather than discarding it, you keep it out of the waste management system. You also avoid buying something new — something that would eventually be discarded and end up in the waste management chain.


TIP

Sometimes reuse requires out-of-the-box thinking beyond your own individual or business needs. What one business or person sees as useless waste, another might see as a useful building block. For example, suppose your company has a large metal shipping container that it no longer needs. Rather than paying your waste collection provider to haul it away, or paying to have it melted down, you could donate it to a nonprofit that uses these containers to create low-cost homes or offices.

Reuse isn't just big things like that, though; anyone can find ways to reuse small items every day. Here are a few simple ideas:

- Buy used. This can be fun and save you money.
- When moving, or packing items for storage, use old cardboard boxes and newspaper when possible.
- Use reusable food containers to store leftovers or small household items.
- Donate unwanted clothing, books, and household items to thrift stores or libraries.
- Repair broken appliances.
- Use rechargeable batteries when possible. But be careful when you throw these away, as they require special handling.
- Compost or mulch organic waste.

Increasing recycling

Recyclable materials have to go somewhere, and if nobody wants to buy them, they often end up going to a landfill. One way you can help increase recycling is to choose to buy products made from recycled materials. When manufacturers have more demand for their products, they will make more of them — and will need more materials to do so.


TIP

You can also increase the percentage of your recyclable household waste by making smart purchasing decisions. Look for products made of recyclable materials, and with minimal, recyclable packaging.

Some people will recycle only if it's really convenient. If you're part of a co-op or neighborhood association, you can lobby for curbside recycling pickup, or at least recycling bins near the dumpsters. Businesses can incorporate recycling bins in the workplace. In all of these situations, it's important to ensure you know which items are recyclable and which are not, so only the right items go into the appropriate bins.

IN THIS CHAPTER

- Understanding waste collection methods
- Differentiating between types of waste collection vehicles
- Learning where waste goes after pickup

Chapter 2
Picking It Up

Municipal solid waste (MSW) collection might seem low-tech when that big truck rolls through your neighborhood, but it's actually a very well-engineered process, with best practices shaped by both research and experience.

In this chapter, you'll learn how waste gets collected. You'll learn about the different kinds of vehicles used, and how collection companies decide which vehicles to use in what areas. You'll also learn about transfer stations, which is where full trucks are emptied, and how collected waste moves on to the next step in the process.

Collecting the Waste

Municipal solid waste can come from residential, institutional, or commercial sources. Each of those tends to have different *waste composition* — that is, their waste is made up of different amounts of the various materials. For example, residential waste tends to have a lot of food, paper, plastic, and yard trimmings, whereas office buildings usually have more paper waste.

Waste collection can be either public — that is, done by municipalities like cities and counties — or private, where a for-profit company does the work.

REMEMBER

If it's within city limits, curbside waste and recycling pickup are often mistaken as being "free," because the cost is sometimes embedded in another bill, such as local taxes or a water or utility bill. Residents outside city limits might have to contact their local hauler to subscribe for routine waste pickup service.

In neighborhoods with houses, trucks usually collect from individual bins for each house. For apartment complexes and office buildings, there are often covered dumpsters that people use. Large commercial facilities may have multiple large bins or dumpsters designed to collect different materials.

Comparing the Collection Trucks

TECHNICAL STUFF

MSW collection vehicles come in various sizes and types, and the right type for a job depends on the amount and type of waste being picked up.

One difference is where the waste enters the truck. Some trucks are side loaders — that is, the cans dump into the truck from the side. Figure 2-1 shows a typical automatic side loader. Some are front loaded, and others load from the rear.

FIGURE 2-1: A side-loading truck.

Another basic difference is whether the truck is manual or automatic. No, not the transmission — the pickup method. With a manual truck, a worker has to pick up each can and physically dump it into the truck. With an automatic, the driver uses a joystick to control a lift that picks up a curbside can and dumps it into the truck — just like a video game. Automated trucks can be front or side loaded. Automated front loaded are generally for dumpsters, while side loaded are for carts from households.

REMEMBER

Automatic trucks are obviously great labor savers and can cut personnel costs dramatically, so why aren't they used everywhere? There are several reasons. One is they can be more expensive. Another is they require the cans to be placed correctly on the curb so the lift can reach them, and that's not practical in some neighborhoods. For example, if parking is allowed along the curb, vehicles would be in the way and would prevent automatic pickup. Yet another is they require a certain amount of space to operate, so they don't work well on narrow streets in some city neighborhoods.

Many manual and semi-automatic trucks are rear loaders, like in Figure 2-2. The workers dump the cans into the back. This type of loading system is the fallback when fully automatic side loading is not an option.

FIGURE 2-2: A rear-loading truck.

If the receptacle being emptied is larger than a regular trash can — like a dumpster, for example — the truck picking it up is usually a front loader. Front-loading trucks have a kind of forklift on the front that can pick up the dumpster, empty it into the truck, and then place it back where it came from. See Figure 2-3.

FIGURE 2-3: A front-loading truck.

When the receptacle is emptied into a truck and immediately deposited back where it came from, that's called *stationary collection.* All the trucks you've seen so far are stationary collection vehicles.

However, when it's a really *big* container, so big not even a forklift can pick it up and turn it upside down to dump it, then what? In those cases, emptying the container at the collection site isn't practical; it needs to be transported to a transfer station. A *hauled container vehicle* (also known as a *roll-off truck*) picks up and transports the entire container — called a *roll-off* — contents and all.

Considering the Costs

MSW collection is quite expensive for a municipality, for many reasons: capital costs for both the trucks and containers, disposal fees, insurance, labor, and fuel. Therefore, anything that can be done to minimize those expenses can make a big difference.

Someone has to drive the truck, and if it's a manual collection vehicle, someone has to pick up the cans and empty them into the truck. Over the course of a year, an extra worker, called a *helper*, can cost upwards of $70,000 when you figure in salary, benefits, insurance, and the like. If you're a city planner, suddenly that new automatic side-loading truck doesn't seem like an extravagance anymore, right? Labor cost and safety have been the major factors in the push toward more automation. More than half the workers in the waste management industry work on collection trucks.

Truck fuel and maintenance is also a huge expense. As you can imagine, waste collection vehicles don't have great miles-per-gallon (MPG) ratings, especially when driving slowly through residential areas and making multiple stops. And the more miles a truck drives, the more maintenance it needs. The push to reduce fuel cost leads collection companies to carefully plan their routes to minimize miles traveled, maximize highway/high-speed miles (which gets better MPG), and have trucks travel uphill when empty and downhill when full.

Using diesel engines in trucks can optimize fuel economy. However, diesel isn't great in terms of emissions/pollution. Diesel was the standard in the past, but many newer trucks use alternative fuels like electricity, compressed natural gas, or biogenic fuels, all of which are more environmentally friendly. Today, more than 17,000 refuse and recycling trucks are fueled by natural gas across the U.S., and about 60 percent of new collection trucks on order are natural gas powered. Increasingly, natural gas created from decomposing waste in landfills is also being used to fuel waste collection vehicles.

Electricity-powered collection vehicles are also gaining in popularity. Electrical vehicles work best in city driving situations because the constant stop-and-go charges the regenerative braking systems.

Where Do the Trucks Go?

When the waste truck rolls away with your trash, it often goes to a *transfer station*. A transfer station is a facility where trucks unload all the MSW they have collected. The waste doesn't stay there for long, though; it's reloaded onto larger long-distance

transport vehicles or sometimes rail cars that take it to its final destination.

REMEMBER

What is that final destination? That depends on a lot of factors, but here are some possibilities:

- **Composting facility:** A facility that handles organic waste in a way that speeds up its decomposition. Chapter 3 looks at composting in more detail.
- **Materials recovery facility (MRF):** A facility where recyclable materials are sorted and sent on to manufacturing facilities to be made into new products. You'll learn more about MRFs in Chapter 4.
- **Waste-to-energy (WTE) facility:** A facility that burns waste, both to reduce its volume and to collect energy from the process. You'll learn more about WTE in Chapter 5.
- **Landfill:** An engineered facility where waste is buried. That's covered in Chapter 5.

IN THIS CHAPTER

- Defining organic waste
- Breaking down composting
- Digesting anaerobic digestion

Chapter 3
Managing Food and Yard Waste

Have you ever tossed an apple core out the car window? You probably didn't think it was "littering" because it would break down quickly. You're not entirely wrong — nature deals pretty well with small amounts of organic waste. After all, when something dies, its matter fertilizes new growth, which is what nature is all about. It's the circle of life!

Some of the stuff we humans do with organic waste, though, is far from nature-friendly. Americans put more than 75 million tons of food and yard trimmings into the MSW collection system each year, according to a 2017 EPA study. And the majority of that ends up in landfills, because it's not cost effective to separate it out of mixed waste and process it differently.

In this chapter, you'll learn about composting, which can turn a minus (organic waste) into a plus (rich soil). You'll discover the difference between aerobic and anerobic digestion of waste, and find out how mulching is similar to — and different from — composting.

What Is Organic Waste?

Organic waste is waste that was originally part of a plant or animal. If it was alive, or came from something alive, it's organic. Organic

waste is different from inorganic waste, like metal, glass, stone, and plastic, because it readily breaks down. With a little time and processing, organic waste can be converted into environmentally neutral or even useful material.

You might hear people refer to plastic as organic — and maybe even the myth that it all comes from dinosaurs. In fact, plastics come from oil, which in turn comes from the remains of plants and animals from millions of years ago. Because of that, plastics are made up of hydrogen and carbon — together known as hydrocarbons — meaning, in the chemistry sense, plastics are organic. However, plastic doesn't break down in nature or compost piles the way food and yard waste do — meaning, in the waste sense, plastic isn't organic.

For MSW management purposes, there are two main categories of organic waste: food waste and yard trimmings. Food waste includes the remains of anything we eat, including fruits and vegetables peelings, animal meat and bones, and oils. Yard trimmings include collected grass clippings, leaves, dead garden plants, and tree branches.

Digging into Composting

One of the best ways to dispose of organic waste is to compost it. *Composting* is a process of breaking down organic waste using oxygen and microorganisms. The process uses *aerobic digestion*, which means oxygen is involved in a biological change process. The primary output of composting is *humus* (pronounced HEU-mus), a nutrient-rich soil that can be used to improve gardens and fertilize plants.

Composting works by exposing organic matter to oxygen and water and letting microorganisms grow and flourish. They feed on organic waste and produce heat and carbon dioxide. Aerating the compost by turning the composting material frequently is necessary to keep oxygen in the mix that microorganisms need to breathe, and by adding water to keep it moist. Under ideal conditions, and with regular aeration, food waste can be fully composted in as little as two to three weeks.

REMEMBER

There's a difference between compostable and biodegradable. *Compostable* (on package labels) means it will break down in the high-heat environment of an industrial compost facility in a time frame similar to food and yard waste without leaving harmful residues. Unless specified, a compostable product will probably not break down in home composting, in the ocean, or as litter. *Biodegradable* means it will break down through the action of living organisms, but it doesn't specify when or where this happens. Because biodegradable is so vague, it has been used on many products and has resulted in accusations of *greenwashing,* which means giving the impression that a product is more environmentally friendly than it actually is. While all compostable products are biodegradable, not all biodegradable products are compostable.

Home composting

Many people have simple home compost bins in their backyards, ranging from no-frills piles on the ground to fancy rotating barrels.

WARNING

Only plant-based organic waste should be composted at home. Appropriate material includes food waste like fruits and vegetables and yard waste like grass clippings and leaves. Animal-based food waste such as meat, animal fats, and dairy will also break down with composting but may have undesired effects as it decomposes: smelling bad and attracting flies, maggots, and scavenger animals — probably what you don't want in your yard. Packaging labeled compostable should be left to commercial composting systems because most backyard compost piles won't get hot enough to break it down.

Decomposing animal products may also contain harmful bacteria. Bacteria dies at high temperatures, but backyard composting isn't hot enough to kill bacteria. Yard waste that contains diseased plants or seeds from weeds can also be a problem for backyard composting. If you create compost from weeds, the resulting compost will make more weeds wherever you spread it. Again, not what you want.

Commercial composting

Commercial composting facilities do the same thing as home composting, but on a much larger and more highly engineered scale. Figure 3-1 illustrates the process.

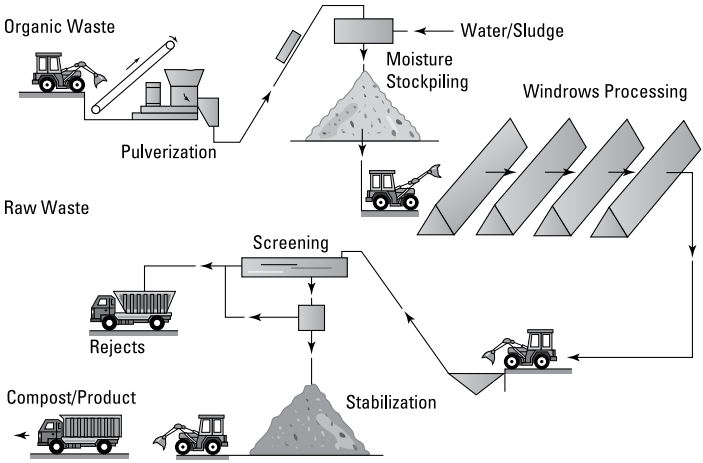

FIGURE 3-1: Commercial composting.

Material biodegrades more quickly in smaller pieces because there's more surface area to interact with moisture and oxygen, so material coming into a commercial composting facility is put through a *pulverizer*, also called a grinder.

Then it is mixed with water and placed into large outdoor *windrows* (piles), which are aerated and watered frequently to keep oxygen and moisture levels high. Some commercial composting facilities also include heaters, which can help kill bacteria, seeds, and other undesirable components.

When the composting process is complete, the compost is screened to separate usable parts from noncompost material, such as metal, plastic, or glass. The screened compost can be sold as a soil amendment or fertilizer.

WARNING

Commercial composting facilities have limited control over the quality of incoming organics, and there are inevitably issues with *contamination.* Compost that contains more than small amounts of inorganic materials like plastic, glass, or metal isn't suitable for reuse or sale.

Digesting Anaerobic Digestion

While composting is aerobic, there are also ways of breaking down organic waste that don't involve oxygen. This biological process is known as *anaerobic digestion (AD)*.

Encouraging solid waste to biodegrade anaerobically generates gases that can be captured and turned into energy. AD facilities that generate a usable compost product are a form of waste conversion.

With AD, organics are placed in an oxygen-free environment, along with microorganisms, moisture, and heat. The bacteria feeds off the decaying material and generates heat, gases (primarily methane and carbon dioxide), and *digestate.* Digestate is the material left over after the microbes consumed everything; it varies in composition but is often nutrient rich and soil-like, similar to humus.

Anaerobic digestion can handle organic material you don't want in your composting bin, like sewage sludge; animal manure; and fats, oils, and grease. The drawbacks are it takes longer and it requires special equipment, so it can't be done at home.

Whereas aerobic digestion mostly produces carbon dioxide, anaerobic digestion primarily produces methane and carbon dioxide. When methane is released directly into the atmosphere, it can be a problem because it contributes to climate change. Methane isn't always bad, though. If captured and managed, it can actually be valuable.

Capturing the gas

Methane is a greenhouse gas, contributing to global warming. However, pure methane is natural gas — it's used for cooking or heating homes. It's flammable, making it a useful source of energy. Further, with AD, you can capture the biogas and put it into tanks or the natural gas pipeline.

Perhaps you're wondering how organic material can become a flammable gas. The entire process is done by different groups of microorganisms that act together to create multiple stages of the AD process. The first stage is *hydrolysis*, which converts complex polymers like polysaccharides, lipids (fats), and proteins into monomers such as sugars, fatty acids, and amino acids. The next phase is *acetogenesis*, which converts monomers into acetates, volatile fatty acids, hydrogen, and carbon dioxide. The final phase is *methanogenesis*, which converts those into methane, carbon dioxide, and water.

AD facilities aren't used more widely because they have some drawbacks and limitations, such as:

- **Waste separation.** Only organic materials can be anaerobically digested, so organics need to be separated beforehand, and this requires labor and money.
- **Contamination can impact digester performance.** The digester's performance can suffer if nonorganic materials are introduced, or if some of the materials contain an inhibitory substance.
- **Uncertain market.** There's not always a viable market for selling digestate, so it may end up in a landfill anyway.
- **Biogas requires cleaning**. If you want to put it into the natural gas pipeline, it has to go through a cleaning process to separate methane from carbon dioxide and remove impurities.
- **Capital costs may be high.** Building an AD system can be costly. As with combustion, this isn't a get-rich-quick business, and it can take many years to recover the initial investment.

Mulling Over Mulch

Yard waste is anything you trim or prune from your yard. It can include dead plants, trees, and branches; grass clippings; leaves; and pine needles. Putting yard waste in your regular trash to be picked up isn't the best option, and many states don't allow yard waste to be placed in landfills. Instead, yard waste is often collected separately and used to create mulch.

Mulch is organic plant material made by shredding or chopping up yard waste. People spread it out over their landscaped areas to retain soil moisture, suppress weeds, improve the look of the yard, and eventually improve the soil's fertility as it decomposes.

Most people don't make their own mulch because they don't have the equipment required (such as a wood chipper or mulch grinder), although if you have a lot of wood to dispose of, you might find it feasible to rent such equipment.

When you mow your yard with a mulching lawn mower, the clippings you leave on your lawn are a form of mulch. Grasscycling isn't just good for the environment; it's good for your lawn.

IN THIS CHAPTER

- Understanding recycling's benefits and barriers
- Learning how recyclables are collected and sorted
- Comparing the ways that different materials are recycled
- Finding out how to be a better recycler
- Dealing with special waste

Chapter 4
Breaking Down Recycling and Special Waste

Recycling can be one of the most beneficial types of waste management — and for good reason. Not only does recycling keep valuable materials out of landfills, but it reduces the need for new resources to be used to make products. Saves time, saves resources, saves the environment. . .what's not to like?

This chapter explains why we recycle — and what the barriers are to making it even more beneficial and widespread. You'll find out how recyclables are collected and processed, and learn what you can do as a consumer to be a better recycler. Finally, you'll learn what to do with special waste types that can't be recycled but also shouldn't be put into the regular trash.

Why We Recycle

Remember, the preferred waste management strategy is to avoid creating new waste. *Recycling* — that is, reusing old materials to avoid having to use new resources — can help to do just that.

REMEMBER

The goal of recycling is to reduce the environmental impact of waste. There are many factors, such as the material characteristics and transportation required, that determine when recycling will achieve this. The key benefits that can be achieved when the proper items are recycled include:

- **Conserving resources:** When something old is reused, it can reduce the need for raw materials. In an ideal world, materials would flow in a circle — from manufacturer, to retailer, to consumer, to recycler, and back again to the manufacturer.
- **Protecting the environment:** Recycling can reduce the need to extract raw materials from the environment, so there's less mining, logging, and refining, which impact land, air, and water quality.
- **Saving energy:** It can take less energy to make something out of existing materials than to harvest new materials.
- **Reducing landfill use:** Items that are recycled reduce the amount of waste placed in landfills.

WARNING

Did you notice that "It saves money" didn't appear on this list? Recycling doesn't always save money because collecting, sorting, processing, and selling recycled materials can sometimes cost more than the value of the material. The prices for recycled materials rise and fall with market demand, and some recycled materials don't have much value at all. On the other hand, some recycled materials consistently save more than they cost. Steel and aluminum cans are like that. They're relatively expensive to make, so when steel or aluminum is recycled, it saves money.

Why Don't We Recycle More?

So, if recycling is so great, why don't we do it more? Why is only 25 percent of our MSW recycled, when 34 to 50 percent of it could potentially be? There are many reasons, but here are some of the most impactful.

- **Lack of availability.** Recycling programs aren't readily available in all municipal areas, and folks in rural areas may have to drive long distances if they want to recycle.
- **Lack of convenience.** Studies have shown that curbside pickup greatly increases participation in recycling programs, but it's not available in all municipalities.
- **Unwillingness to do the labor.** People think recycling is a great idea in the abstract, but when it comes down to actually doing the extra labor required for it — like rinsing out dirty containers and placing them in separate bins — they often lose their enthusiasm.
- **Confusion.** Many people who would like to recycle are intimidated because they don't understand what can be recycled and how to do it. And, the rules keep changing.
- **It's sometimes not cost effective.** Just because a material *can* be recycled doesn't mean it's profitable to do so.

NATIONAL SWORD: HOW CHINA CHANGED THE RECYCLING MARKET

Every country has its own regulations regarding waste and recycling, and a change in one country can dramatically impact the waste and recycling industries in other countries. This was the case in 2018 when China launched its National Sword policy, which banned the importation of 24 kinds of solid waste that included all mixed plastics and mixed paper and imposed a new contamination standard of 0.5 percent or less on cardboard.

These measures significantly affected recycling programs in the U.S. and in the rest of the world, because recyclers had to quickly search for new outlets for their recyclable materials. These new outlets (which included Thailand, Malaysia, Vietnam, Taiwan, Indonesia, India, and others) became overwhelmed with the large increase of materials being imported, and began imposing their own restrictions and banning certain types of imports. As a result, the supply exceeded the demand for many recyclable materials, and the markets for some of these materials crashed, with some prices dropping below $0. A potential silver lining with this policy is that it's providing opportunities to expand domestic markets for recyclable materials.

- **Contamination.** If recyclable materials aren't carefully sorted and processed, the recycled output can contain unwanted materials, such as trash or unacceptable recyclables, that contaminates it and makes it unusable.
- **Lack of end markets for recycled material.** Sometimes recyclable materials have no manufacturers who want to buy or use it.

Collecting Recyclable Items

The following sections look at some of the different ways recycling programs collect and sort material.

Curbside pickup

In some areas, waste collection companies also offer curbside recycling pickup. They may provide separate cans or bins in which to place your recyclable items, and a different truck may come through to get them. The advantage of curbside pickup is more people will recycle because it's less work for them. The disadvantage is it costs more to provide the labor, fuel, and, in most cases, extra truck to do the collection.

Drop-off centers

In areas where curbside pickup isn't available, people who want to recycle must take their items to a drop-off center. These centers are often located at transfer stations, grocery stores, shopping centers, or other convenient locations that are "on the way" to wherever you're going.

Single stream versus source segregated collection

REMEMBER

Source segregated collection is the system where consumers separate materials by type. Drop-off centers usually do source segregated collection, with separate bins or dumpsters for each material. Source segregated collection is also common in businesses and public spaces where people are discarding individual items. For example, at an airport you might see a line of trash

cans, each for a certain type of recyclable material, such as aluminum or glass.

When all the different recyclable materials are collected in a single bin, or a single pass, that's known as *single stream* collection. A lot of curbside recycling collection is single stream because it's the least labor intensive for consumers (so you get more people putting more things in the recycle bin).

A hybrid between single stream and source segregated is dual stream. Some curbside collection is dual stream, where residents separate their recyclable paper from their containers but don't have to separate it further.

There are some significant drawbacks to curbside collection. One of the biggest is contamination, especially plastic bags, shredded paper, and batteries.

Materials Recovery Facilities

Collection vehicles drop off your recyclables at *materials recovery facilities (MRF,* pronounced "murf"). These facilities sort recyclable materials by category and then sell sorted and baled material to be manufactured into new products. For example, aluminum might go to a plant that makes new cans, plastics might go to a facility that shreds and melts plastic to make carpet, and so on.

REMEMBER

A *single stream MRF* accepts a variety of recyclables from a single stream collection operation. The facility then runs the material through a series of separation operations — some automated and some manual. For example, a magnet might extract steel, the aluminum will be sorted by a type of technology called an *eddy current,* lightweight materials might get picked up with air-powered pneumatic systems (basically vacuums), and plastics might get diverted by optical sorters, or air pressured jets, or even robots! Figure 4-1 illustrates a typical workflow in a single stream MRF. Other facilities are more specialized and may handle only one or two types of material. A dual stream facility, for example, accepts fiber and containers as separate streams.

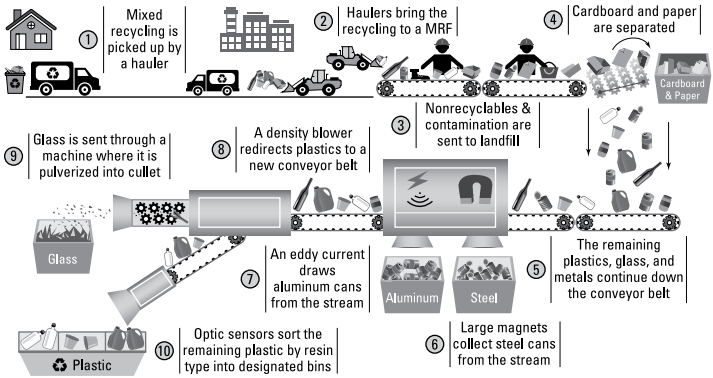

FIGURE 4-1: How a MRF separates recyclables.

How Recyclable Material Is Processed

REMEMBER

Material can't accurately be called "recycled" until it's actually used to make something else. Up to that point it's just "recyclable." Recyclable material has no special value, other than its potential. It could still end up in a landfill, for a variety of reasons. Unrecyclable materials sorted out by MRFs to be sent to landfills are called *residuals*.

Assuming all the factors are a go, and the material is recycled, how does that work? As you might guess, it's different for every material type, but here are some examples.

Recycling paper

About 35 percent of the world's felled trees end up as paper. Recycling paper helps the environment by saving energy that would have been expended to harvest, transport, and process trees. By weight, paper recycling makes up more than half of what's in recycling carts. Almost a third of paper recycling is cardboard.

TECHNICAL STUFF

Paper recycling is a multistep process that starts by breaking down the old paper using water and chemicals, and then shredding and heating it to make an oatmeal-type slurry called *pulp*. The pulp is filtered, cleaned, and bleached, and then pressed and dried into tissue or new sheets of recycled paper.

Recycling plastic

At the MRF, plastic is sorted by type — polyethylene terephthalate (PET, also known as #1) is sorted separately from high-density polyethylene (HDPE, also known as #2), for example. From there, plastic goes to a manufacturing facility where it's thoroughly washed, ground, and then melted down and formed into new products. This type of mechanical recycling is good for remaking plastic into a new plastic product with the same kind of resin — old PET being made into new PET, old HDPE being made into new HDPE, and so on. However, even if they are the same kind of resin, they can be made into different items, such as turning old water bottles into toys or clothing. Plastic is currently less than 20 percent of material in a recycling cart.

Chemical recycling, which is still a budding industry, is an innovation that might allow more types of plastic to be recycled. In chemical recycling, strong chemicals are applied to plastic to change its composition. Most plastic items are made of *polymers*, which means many identical molecules are bonded together. Polymers are made by combining *monomers*, which are the building blocks, the individual molecules. Chemical recycling applies a chemical, such as alcohol and a catalyst, to convert polymers back to monomers. These monomers can then be reused to make new items that may be quite different from the original plastic items such as specialty chemicals, waxes, or even other types of plastic. If successful, chemical recycling facilities might accept a wider variety of materials. However, this application is rare, and it's still pretty new. It will probably experience some growing pains as it develops.

Recycling metal

Recycling steel and aluminum saves manufacturers lots of money. The process of making new steel from iron ore or aluminum from bauxite ore is quite expensive, and using recycled materials can save significant money. It's also environmentally friendly, reducing energy consumption by an estimated 75 percent a year. Even though by weight these metals traditionally are the most valuable part of the recycling cart, they make up the smallest portion at less than 7 percent of all materials.


TECHNICAL STUFF

Recyclable steel is compacted down as much as possible to make it easier to handle and transport, and then it's shredded into small pieces and *smelted*, which melts the shredded steel down into liquid form. While it is still liquid, the steel is refined to remove as much of the impurities as possible. Then it's poured into containers and allowed to cool and solidify, either into finished products or into generic bar stock that can be melted down again at a manufacturing facility and poured into specialty molds.

Aluminum goes through a similar process. It's shredded, cleaned, and melted, and any impurities are removed. Depending on the product being created, the composition of the aluminum alloy may be adjusted by adding copper, zinc, magnesium, or silicon to the liquid aluminum. Then it's poured out into ingots, which can be transported to factories to make new products. A typical aluminum beverage can contain about 73 percent recycled aluminum, and recycling a can results in energy savings of more than 90 percent.

Recycling glass

Recycled glass can be substituted for as much as 95 percent of new raw materials when making new glass. Glass containers make up just a little more than a fifth of the recycling cart.


WARNING

Glass food and beverage containers are 100 percent recyclable, but some other types of glass aren't because of the additives introduced during their manufacturing processes. For example, windows, crystal, and ovenware glass can cause problems when recycled and therefore aren't acceptable in the recycling bin.

Not all recovered glass ends up in new glass bottles and jars. Recovered glass has many other possible uses, such as in construction materials and supplies such as tiles, bricks, and concrete; swimming pool filters; paint and plastic additives; and fiberglass insulation.


TECHNICAL STUFF

After the MRF, glass might go to a secondary processing facility where contaminants, such as metal, shredded paper, or ceramics, are removed.

Next, the glass goes through a series of hammers that break it into small pieces. Then the pieces go through a revolving screen that sorts them by size and removes any residual paper labels.

Anything that doesn't shatter and pass through the screen is removed and recycled separately. From there, the glass particles go through a heated air dryer that burns off any sugar or bacteria and loosens any remaining glue from old labels. The clean, dry glass particles are then screened again to sort them by size, pulling out any large particles for more pulverizing. An optical sorter separates the glass into three colors — flint (clear), amber (brown), and green.

The result is glass cullet in a consistent particle size, ready to be melted down to make new glass.

Recycling Effectively

Many people *try* to recycle, but a lot of them don't do it effectively. And doing it wrong can actually be more harmful than doing nothing at all, because you have the potential to contaminate the process. Here's some information that can help you become a better recycler.

Identifying recyclable materials

Product manufacturers have tried to make recycling easy for consumers by placing a recycling symbol on products that are recyclable. Here it is in Figure 4-2.

FIGURE 4-2: The universal recycling symbol.

WARNING

Don't let this symbol lull you into a false sense of confidence, though. It doesn't always mean the item is actually recyclable in your area, or sometimes recyclable at all. It only means the manufacturer *suggests* that some part of the item can be recycled. For plastic items, the recycling symbol with a number inside doesn't even mean it's recyclable. It only tells you what kind of plastic it is and has nothing to do with whether it can be recycled.

TECHNICAL STUFF

For plastics, the number is called a *Resin Identification Code (RIC)*. The number ranges from 1 to 7. The ones with 1 or 2 are widely recyclable. The ones that are *not* usually recyclable are 3, 6, and 7. The remaining ones, 4 and 5, are questionable; some recycling centers do accept them, but many don't. Sometimes it depends on the shape of the container as well. Therefore, to know what's recyclable, you need to check with your recycling service provider.

WARNING

Don't fall into the *wishcycling* trap, where you throw something into the recycling bin you aren't sure about. You might be thinking "I'll recycle it just in case, and if it's not usable, someone will weed it out." This can do more harm than good, because nonrecyclable items can contaminate other materials and even damage a recycling facility's equipment. Think (and research) before you throw. And if you don't know, remember the maxim: If in doubt, throw it out.

Preparing and sorting items

TIP

It's important to avoid putting contaminated recyclables into the system. Depending on the degree of contamination, this can be worse than not recycling at all, because contamination can make entire batches of recycled material unusable. Contamination can include simple organic material like food scraps and dirt, or, on the extreme end, toxic chemicals such as pesticides.

And remember, just because something is recyclable somewhere doesn't mean it can go in your recycling bin. For example, plastic bags may be recyclable at the grocery store, but they damage MRF equipment, so they don't belong in the recycling cart. Also, put recyclables in the cart loose, not bagged! Other big no-nos include shredded paper, batteries, liquids, and *tanglers* (things like garden hoses, wires, and ropes). Although paper might be good before it's

shredded, it just makes a big mess at the MRF. And batteries can spark fires!

Dealing with Special Waste

Some waste is considered *special waste*, meaning it requires special handling and shouldn't be placed in the regular recycling or trash. Special waste isn't always recyclable, but it is sometimes when collected as a separate stream.

Special waste can be from commercial, industrial, or residential sources. On the residential side of things, special waste commonly includes electronic waste, tires, paint, syringes or other medical sharps, propane and helium tanks, batteries, fluorescent light bulbs, thermostats with mercury, and household hazardous waste.

Household hazardous waste includes items such as solvents, pesticides, and pool chemicals. These are usually hazardous items generated in small quantities by consumers.

Old prescription drugs may also require special handling. Contact your municipality for advice on how to dispose of them.

Commercial and industrial businesses usually contract with a hauler to remove their special waste, while consumers may need to take their special waste to a designated drop-off facility. Some important tips for disposing of special household waste include the following:

- **Leave material in its original container if possible.** That's important so the facility can accurately identify the item and handle it appropriately.
- **Observe the rules for dropping off special waste.** Don't leave your waste outside the facility's closed doors in the dead of night; drop off only during operating hours.
- **Expect to be identified.** Don't be surprised if you have to provide a photo ID and your contact information. This is normal.

REMEMBER

Special waste isn't the same thing as hazardous waste. *Hazardous waste* is waste with properties that makes it dangerous or potentially harmful either to human health or to the environment. In the U.S., hazardous wastes are regulated by law and are subject to special handling rules. However, hazardous waste is also regulated by quantity, and households generate very small amounts of hazardous waste. That's why it's called household hazardous waste. While it's best to reduce the amount generated, households are not subject to the same stringent handling for hazardous waste that businesses are.

IN THIS CHAPTER

- Converting waste to energy
- Exploring how landfills work
- Regulating landfills
- Closing landfills

Chapter 5
Digging Into Waste-to-Energy and Landfills

A landfill is the last stop on the waste train. After all the efforts to handle waste in some other way have been exhausted, it goes into a landfill.

In this chapter, you'll learn how landfills are constructed and maintained, and how proper landfill regulation and management protects people and the environment. But first, take a look at one last thing we can do to waste before consigning it to a landfill: converting it to energy.

Converting Waste to Energy

If you have some waste that's probably headed for a landfill, it would be great if you could: 1) reduce its volume, 2) turn it into something useful, and 3) make a little money from doing so. That's the idea behind waste conversion.

The two main types of waste conversion are:

- **Waste-to-energy (WTE):** Burning waste to generate heat (and steam), which is then used to generate electricity.
- **Landfill gas-to-energy (LFGTE):** Capturing methane produced from anaerobic degradation of organic materials in landfills and using it to create electricity, heat, or fuel.

LFGTE will be discussed in the landfill section of this chapter, but take a look at WTE now.

Waste-to-energy, which is also called *thermal conversion* or *combustion*, burns waste in a controlled environment that captures the resulting heat and uses it to generate energy.

Figure 5-1 shows the general process. Waste arrives at a bunker and is loaded into a furnace. Burning the waste turns it into ash, greatly reducing its volume and weight, which is the first benefit. The ash residue from the furnace is processed to remove recyclable scrap metals. Meanwhile, the heat from burning the waste generates steam that turns turbines to create electricity. Some facilities use the steam to heat local businesses and homes. This is a secondary benefit extracted from waste.

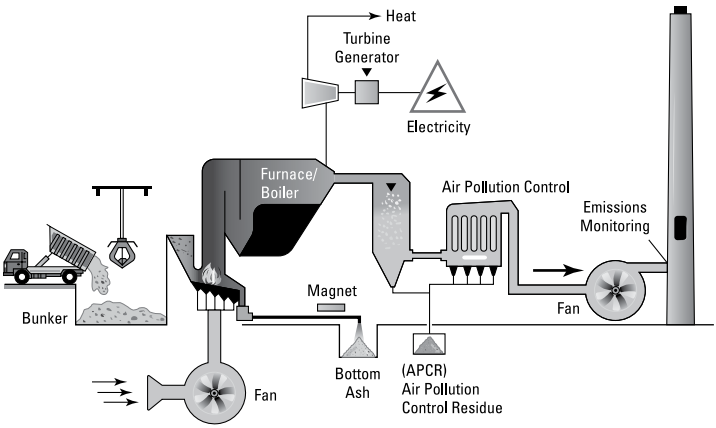

FIGURE 5-1: The combustion process.

Combustion is an aerobic process (that is, it needs oxygen), so big fans constantly pump air into the furnace. That air gets dirty, so it goes through post-furnace air pollution controls before it's released back into the environment.

Only about 9 to 13 percent of MSW goes through an energy recovery facility today, with only 75 facilities in the U.S. Why is it not more popular? Here are a few reasons:

- **Availability of landfill space:** Waste-to-energy is more cost competitive relative to landfills in areas of the U.S. where populations are dense and the land is limited, such as in the Northeast or Florida.
- **Public misperception:** Everyone wants waste management, but nobody wants it in their backyard. WTE facilities were required to install sophisticated air pollution control equipment in the 1990s, but before that, they gained a reputation for being high polluting, a stigma which still persists to this day despite highly engineered systems designed to remove pollutants from the emitted air.
- **Cost to build:** It costs a lot to build a WTE facility ($100 million or more). In addition, most WTE facilities were publicly financed with regulations directing waste to those facilities to recoup their costs.
- **No quick profit:** A typical WTE facility can generate about 550 kilowatt hours (kWh) of energy per ton of waste. At an average price of 4 cents per kWh, a ton of waste is worth about $20 to $30. There's also money to be made through tipping fees (that is, the price each truck pays to unload there) and selling recovered scrap metal, but it's by no means a get-rich-quick business venture.

Digging through the Landfill Layers

A *landfill* is the final stop for waste. It's a facility where waste materials that can't be recycled or otherwise used are placed. It includes multiple safeguards that prevent decomposing waste from harming the environment or creating a public nuisance.

REMEMBER

When most people think of landfills, they picture open dumps with vermin and litter everywhere, but that's not an accurate picture. Today's landfills are highly engineered and managed systems that allow waste to decompose slowly over time in a covered, anaerobic environment designed to protect the soil, air, and water around it. In this section, you'll learn how modern landfills are structured, regulated, and eventually decommissioned.

Regulating landfills

Landfills in the U.S. are subject to some fairly strict Environmental Protection Agency (EPA) regulations designed to ensure public safety and protect the environment.

TECHNICAL STUFF

The EPA's Resource Conservation and Recovery Act (RCRA) Subtitle D section covers MSW landfills. Subtitle D provides specific requirements for how landfills should be constructed and monitored in order to prevent soil and water contamination. In addition, the EPA's Clean Air Act New Source Performance Standards Subpart XXX and Emissions Guidelines Subpart Cf regulate air emissions from landfills.

Keeping it contained – the liner system

A landfill usually starts with a big hole in the ground, with *native soil* beneath it (that is, the soil that was already in the ground at that level before the landfill came). However, if the water table is high, the landfill might be built from the ground up. You can't just toss waste directly onto the native soil, though, mainly because of leachate. *Leachate* is the liquid that enters the landfill (from rainfall), that's already in the MSW, or that generated during decomposition. It can pollute the soil underneath the waste, as well as any groundwater sources below it, or runoff to nearby surface water. To prevent that, the landfill builders must put down multiple layers of protection to keep the waste separated from the environment. In general, the layers of protection are as follows:

The native soil is graded to a controlled slope draining to a low point. On top of the native soil, the builders add a layer of compacted clay. It's a highly dense type of soil that discourages gas and liquid from passing through. Above that is a thick plastic sheet called a *geomembrane* that liquid and gas can't penetrate and that chemicals in the leachate won't damage.

Figure 5-2 shows a conceptual model of the layers in a typical landfill. The upcoming sections explain these layers.

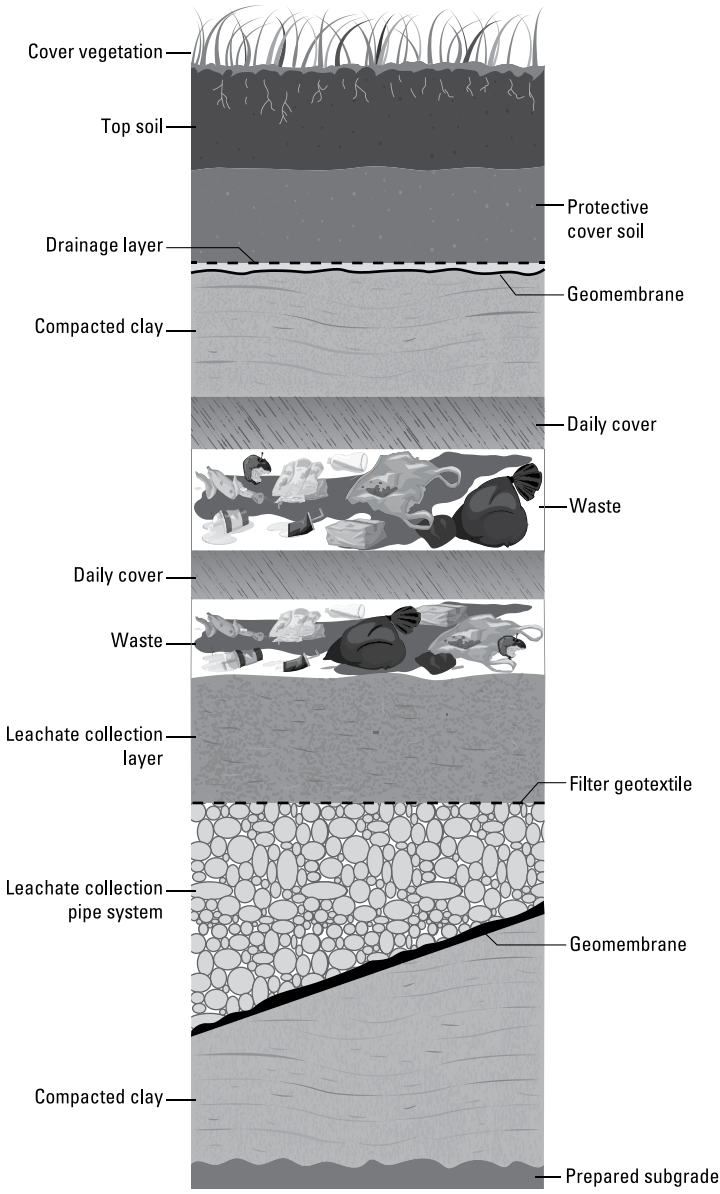

FIGURE 5-2: Landfill layers.

Leachate collection system

Just above the composite liner system is a leachate collection system that drains leachate to the low point. From there, it is pumped out of the landfill and treated.

The first part of that is the leachate collection pipe system, which consists of perforated pipes surrounded by a bed of gravel. The pipes carry leachate to low points called *sumps*, and from there, pumps remove leachate from the landfill. The collected leachate is then treated, usually offsite at the same wastewater treatment plant household wastewater is treated.

Above the collection pipe system are some other special purpose layers that provide additional protection. The filter geotextile layer is made up of a feltlike fabric. It helps separate solid particles from liquid, which prevents clogs in the pipes. Above that is a layer of sand or gravel, or a thick plastic mesh called a *geonet*, which allows leachate to drain down via gravity to the pipe system.

The working landfill

At this point, the landfill can begin accepting waste, which is compacted within a small area daily. At the end of each workday, the waste is covered with about 6 to 12 inches of soil or some other approved material, such as plastic tarp, or foam.

Compacting waste and applying daily cover have several benefits. Compacting reduces volume, which allows more waste to be placed in the same area. Daily cover reduces air emissions, odors, and wind-blown litter, and it discourages scavengers.

Landfill gas

AD generates methane, which is a greenhouse gas and shouldn't be vented into the atmosphere. Therefore, gas collection pipes are installed in the landfill (not pictured in Figure 5-2), allowing gas to be collected and managed in a controlled way. The pipes lead either to a plant where methane is turned into energy, such as electricity or compressed natural gas, or to a flare station where gas is burned off.

Landfill cap system

When waste has reached its design height, that spot in the landfill is considered full. Workers then apply additional protective layers to ensure waste is encapsulated and water and air from above don't reach the waste.

These layers (from lowest to highest) consist of more compacted clay, another geomembrane, and another drainage layer. There may also be another geotextile fabric layer.

Protective cover

Closed landfill areas are typically covered with another thick plastic liner and vegetation. It's visually pleasing and protects the underlying layers from erosion.

This protective cover consists of some protective cover soil and nutrient-rich topsoil, on which native grasses and shrubs are planted. From the outside, a closed landfill just looks like a gently sloping grassy hill. You would never know there's decomposing waste under it.

Closing Landfills

Responsible landfill stewardship doesn't stop when the landfill is full, and the management organization certainly doesn't just walk away from it. There are strict regulations regarding landfill closure and monitoring.

The landfill management organization must obtain a permit before it can close a landfill, and to get the permit, it must submit a conceptual plan for the closure that meets all current regulations and explains how it will continue to safeguard the environment and monitor the site. The plan must address issues such as slope stability, drainage, and gas control.

After closure, the landfill moves into a long-term care phase, where it's monitored for at least 30 years under federal and most state requirements.

After closing, landfills generally need to remain as open space. But that doesn't mean they can't be useful. Some old landfills have been turned into parks, solar farms, or golf courses. In at least one case, a landfill was even made into a ski hill.

Chapter 6
Ten Misconceptions about Waste Management

There's a lot of inaccurate information about waste and recycling. Maybe you even believed some of it before you picked up this book!

This chapter lists the top ten misunderstandings people often have, and attempts to dispel them.

Recycling makes money. While recycling is often the best option for managing material, it isn't always. Sometimes it costs a lot of time, energy, and money to collect, process, and market recyclables for little, or negative, revenue.

The chasing arrows symbol means an item is recyclable. This symbol doesn't always mean you can recycle the item in your area — only that the manufacturer *suggests* the item can be recycled. With plastic, however, the key to determining an item's recyclability is governed by its shape and the numeric code inside the symbol.

Packaging labeled compostable or biodegradable goes in your home compost bin. Packaging labeled compostable is intended for industrial composting, not your backyard bin, because it doesn't generate enough heat to break down these products. If these items aren't accepted in your municipal composting, place them in your trash bin.

If you don't know if something can be recycled, it's best to let recyclers sort it out. Nonrecyclable items can contaminate other materials, damage equipment, and potentially cause more waste. Think before you throw, and if you're uncertain about an item, check with your service provider or place it in your trash can.

The trash can is for everything you can't recycle or compost. Improperly disposing of electronic, hazardous, or medical waste can be dangerous, both to waste workers and the environment. One major no-no is lithium-ion batteries, which can spark fires in trucks and facilities.

Landfills are the bad guy. While they're not anyone's first choice for waste disposal, landfills are necessary, because not all waste qualifies for one of the more preferred disposal methods. Also, as waste decomposes, methane often can be used for fuel and/or energy.

Landfills leak into groundwater. While some people remember old open dumps that leaked into groundwater, this perspective is antiquated. Modern landfills are designed to protect human health and the environment by properly containing waste.

WTE facilities just spew out air pollution. Decades ago, incinerators reduced waste to ash without air emissions controls. However, modern WTE facilities are subject to strict requirements and equipped with pollution control equipment. They also generate electricity or steam, reducing the need to use fossil fuels for energy.

Food waste is unavoidable. We're all guilty of tossing uneaten leftovers, but most (edible) food waste can be prevented by following best practices like mindful purchasing, donating edible but unwanted food, and freezing meals.

Thinking and talking about waste isn't fun. This book disproves that myth, right? Hopefully, you've had a good time reading this book and learned some interesting facts.

Get the scoop on waste management and recycling!

Where does my trash go after the big truck picks it up each week? How do I know what kinds of plastic can be recycled? Should I be composting my lawn trimmings? If you have ever wondered how waste management happens — and what consumers can do to make it work better — this book is for you. When you understand what happens to the items you discard — and where they end up — you can make more responsible and ethical choices about waste and recycling. You'll also learn some fun facts to impress your friends and family!

Inside...

- Where trash goes after curbside pickup
- What can be mulched or composted
- How waste is turned into energy
- Common recycling mistakes
- What happens inside a landfill

Faithe Wempen, M.A. is a professional writer and the author of over 150 retail and academic books.

Go to Dummies.com™
for videos, step-by-step photos, how-to articles, or to shop!

ISBN: 978-1-119-74859-5
Not For Resale

for dummies®
A Wiley Brand

WILEY END USER LICENSE AGREEMENT

Go to www.wiley.com/go/eula to access Wiley’s ebook EULA.