The ins and outs of curbside recycling programs

In recent years, numerous municipalities in the United States and abroad have implemented either mandatory or voluntary curbside recycling programs. In most of these programs, household trash is sorted into paper, metal (steel and aluminum), and plastic products prior to its collection and then transported for processing into recycled materials. While the materials are not recycled at the curbside, the term *curbside recycling* generally now represents both the collection and sorting phases for these household materials.

Before we get into specifics, please note that this particular article will only address the third R of solid waste management—recycling—and not reducing or reusing materials (3Rs = reduce, reuse, recycle). These three processes are all means by which waste generation is decreased, but each is distinctly different from the others. The definition of *recycling* is limited to the collection of existing materials or products that are then used as the raw source, or stock, for the production of new materials. The materials collected are diverted from the waste stream, thus decreasing the total amount of solid waste generated.

Why have curbside recycling programs risen dramatically in the last 20 years?

While recycling has existed for centuries (think of blacksmiths, jewelers, and glassblowers collecting leftover materials to use as melt sources for new products), the major factors that have contributed to dramatic increases in recycling rates over the past 20 years include (1) public and government recognition of conservation of energy and resources through recycling, and (2) public and government recognition of problems related to methods of modern waste disposal, such as landfills and incineration (see Figure 1).

During both world wars, public recycling campaigns spread to households in order to reclaim recyclable resources that were in short supply. Then, in the early 1970s, recycling efforts increased due to rising energy costs, and recycling was publicly promoted for the first time as a method of energy conservation. Depending on the material to be recycled, significant amounts of energy are saved by using recycled materials to produce subsequent end products, as opposed to using "virgin" stock (see Figure 2). For example, it is estimated that producing a new aluminum can from recycled aluminum saves 95% of the energy that would be required if that same can were produced from bauxite ore. Glass, paper, and other metals such as steel have less impressive energy savings, but still demonstrate a reduction in the energy required to produce new materials from virgin stock. For paper products, the passage of the U.S. Clean Water Act in 1977 significantly

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boosted paper recycling efforts because recycling already-bleached paper fiber reduces the need for water used in paper production.

In the 1980s, questions were raised in environmental communities about the potential for plastics (including polystyrene, the type of foam that is used in most food containers and foam cups) to be recycled. Dow Chemical Corporation and other manufacturers responded with an information campaign about the recycling potential of all plastics. Since that time, paper, glass, metal, and plastics have been included in recycling campaigns worldwide. While many types of plastics and foam are recyclable, not all are collected and actively processed for recycling (see Problems With Plastics section below).

Problems with landfill contamination have been well documented in the last two decades, and resulted in the development of new, safer technologies and passage of strict laws related to landfill construction. However, no single event in our recent history had as much of an impact on drawing public attention to landfills than the garbage barge *Mobro*. In 1987, the *Mobro* began its journey from Islip, New York destined for Morehead City, North Carolina. The local landfills in Islip were nearing capacity, and Morehead City was working on a system for turning garbage into methane fuel and contracted to accept Islip's waste to use in the project. While *Mobro* was at sea, Morehead City learned that a few of the waste containers on the ship contained hospital gowns, syringes, and disposable diapers, and therefore they refused to accept the entire load when it attempted to dock in North Carolina. The *Mobro* then set sail for additional ports, attempting to find one that would accept its load. After four months at sea and being rejected by six states and three countries, the *Mobro* was granted federal permission to dock (but not to unload) in New Jersey. Following a court battle of several more months, the *Mobro's* load was finally taken to an incinerator in New York and the ash transported back to Islip to be deposited in their landfill. The story of the *Mobro* created international concern for solid waste disposal, highlighted the fact that waste disposal had now become an interstate business, and spurred numerous news and investigative reports into the future of solid waste disposal.

Do we really have a landfill crisis?

With the release of reports on the potential for plastics recycling and *Mobro's* journey occurring around the same time, it is understandable that the late 1980s became a time of intense scrutiny on landfill availability and diverting waste from landfills. Fears of being "buried by garbage" were wide-

FIGURE 1 **Municipal solid waste (MSW) recycling rates, 1960–2003 (EPA 2006)**

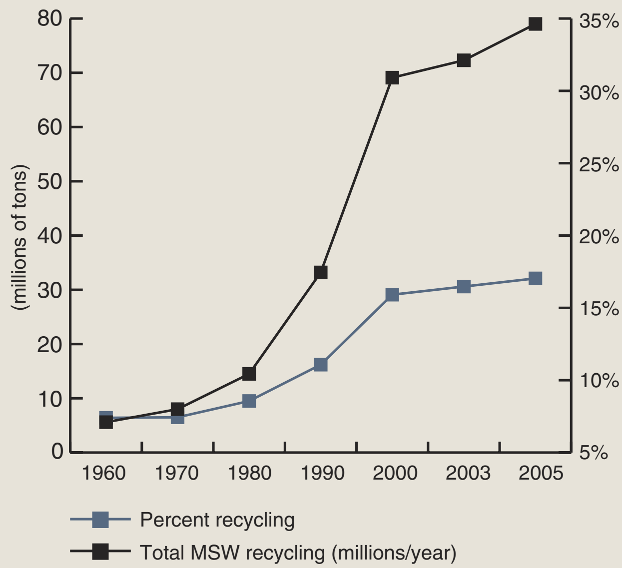

FIGURE 2 **Energy savings per ton recycled materials (NRDC 2006)**

(Relative to energy required for virgin production)

Materials	Grade	% Reduction of energy	Million BTUs	Equivalent in barrels of oil	Tons CO_2 reduced
Aluminum	Not applicable	95	96.00	37.2	13.8
Paper	Newsprint	45	20.90	3.97	–0.03
	Print/Writing	35	20.80	3.95	–0.03
	Linerboard	26	12.30	2.34	0.07
	Boxboard	26	12.80	2.43	0.04
Glass	Recycle	31	4.74	0.90	0.39
	Reuse	328	50.18	9.54	3.46
Steel	Not applicable	61	14.34	2.71	1.52
Plastic	PET	57	57.90	11.0	0.985
	PE	75	56.70	10.8	0.346
	PP	74	53.60	10.2	1.32

spread, and recycling of household wastes was advocated as a critical intervention that would assist the United States in avoiding this fate.

However, whether the United States is indeed facing a landfill crisis has been hotly debated by individuals representing the Environmental Protection Agency (EPA) and pro-recycling and anti-recycling groups. Daniel K. Benjamin of Clemson University has performed extensive analyses of the statistics on landfills and has concluded that the amount of landfill space now available in the United States is greater than ever before (Benjamin 2004). He concludes that while the overall number of landfills has decreased, significantly larger ones have replaced numerous small landfills, thus increasing the overall capacity in the United States. Benjamin attributes the perceived crisis to have been generated by a misinterpretation of the statistics. However, in many states (like New Jersey), there is extremely limited landfill space readily accessible to residents, creating a local scarcity and relative shortage that has resulted in making trash disposal an interstate business.

Regardless of which side one is on in relation to whether there is a landfill space crisis, landfills represent a nuisance for those who live near them, older landfills and landfills not properly protected from leachate of hazardous materials can present health hazards, and disposing of waste in landfills is a costly financial proposition. Any increase in recycling of materials creates what is called *diversion* (materials not being placed in landfills), and that is considered a significant positive benefit of recycling.

How much does it cost to recycle household materials?

While recycling has definite positive impacts for the environment, one cannot ignore the economics and negative environmental—yes, environmental—impacts of some curbside recycling programs.

Depending on the method used to collect, sort, and transport the materials for recycling, curbside recycling programs can be very costly to run in terms of human labor and facilities. Curbside recycling pickups by sanitation personnel can require more person-hours than the number needed to pick up an identical amount of waste not destined for recycling. A scenario: If ABC Township normally picked up trash once per week, and then added a separate run to pick up recyclables once per week also (even if the run occurs on the same day), the number of labor hours spent in trash pickup per week has doubled. This increase in labor time is often invisible to the households since the number of days that trash is collected typically remains the same; it is only the number of runs per day that increases. Many communities have experienced this increase in labor, and come up with creative ways to lessen its cost. Examples include communities with two trash pickups per week decreasing regular trash pickup to once a week, with the second pickup day for recyclables only; and, using trucks with compartments so household waste and recyclables can be picked up on the same run but not commingled. On an environmental note, if trucks used to pick up the materials run on fossil fuels, the increased number of runs means increased airborne pollution.

The process of sorting recyclables that have already been sorted by the household occupants is also a very labor-intensive process (see *www.startribune.com/1741/story/64339.html* for a great online video of a functioning recycling plant). Because there are a number of types of plastics, for example, people must sort through the plastics and isolate those that are recyclable from those that are not. Thus, recycling involves significantly more human labor than traditional waste disposal.

Some economists estimate that the financial cost of recycling programs exceeds the cost of traditional waste disposal in many communities where landfill space is at a lower price (such as in some western or midwestern states), and advocate for a complete examination of all the costs and benefits of curbside recycling programs before and during their implementation.

How are household materials recycled?

Glass

Like all curbside recyclable materials, collected glass is generally taken to a processing center where it is first sorted based on color (clear, green, brown, and so on). Then it is crushed into very small pieces called *cullet*. The cullet is loaded into trucks or railroad cars and shipped to a processing company where it is cleaned and made ready to be sold to a glass factory. At the glass factory, the cullet is mixed with sand and other materials, heated, and the molten glass used to form new containers that are then shipped to businesses that will fill or sell them. The new glass is equally strong as glass made without cullet; glass can be recycled forever without loss of quality.

Metal Cans

Because we are focusing exclusively on curbside recycling, we'll talk only about the recycling of metal cans and not other metal sources (like sheet metal, copper wire, and other larger materials). However, it should be remembered that industrial metals are very large sources in the total recycling stream.

Once metal cans arrive at the processing center they are sorted: typically separated first from glass, paper, and plastic by manual labor, and then sorted by machine. Often magnetic devices are used for this purpose—because steel is magnetizable and aluminum is not, using large circular magnetic belts attracts the steel cans, and the aluminum ones fall away into another container.

Once the metal is separated, the cans are usually crushed and transported to a manufacturing center. At the manufacturing center, the cans are shredded and then melted by a special furnace. Aluminum is melted into *ingots* (each individual ingot can be used to make more than one million new cans); steel is made into sheets that are then shaped into cans.

Paper

Paper is collected, sorted by hand and sometimes by machine (blowers are used to lift paper out of the recycling material stream), and then taken to a mill that uses the various paper types. At the mill, the paper is taken to a pulper, shredded, and mixed with water and chemicals to remove ink. This very liquid mixture (99% water and 1% fiber) is called *slurry* and resembles a thick milkshake.

Once the ink is removed, the mixture is bleached and virgin pulp from trees is added. The mixed pulp is pumped between two moving wire screens, removing water from the top and bottom, and forming a mat. The mat is sent through pressing and drying rollers to remove more moisture, ironed for smoothness, packed into cartons or rolls, and delivered to factories so it can be made into a final product.

Plastics

As for glass and metals, plastics are sorted based on the type (to be discussed fully in the next section), and those that are recycled at the local level are crushed and baled for shipping to a processing plant. There, they are washed and either shredded or made into pellets to be included in new end products.

Problems with plastics

Recycling plastics is more complicated than the other materials due to the high variety of plastic types. There are hundreds of modern plastics with only seven routinely labeled with a triangular arrow and number inside. Of the seven types of plastics routinely labeled, very few actually have a market for recycling (Bogner 2005). Thus, even though a plastic container may have a recycling symbol and number on it, the real truth is that it very well may not end up being recycled. The reason for this comes down to simple chemistry: Plastics are long chain molecules and each type of plastic has a different molecular composition. Because different molecules do not mix with others when plastics are recycled, just as aluminum cannot be combined with glass when recycled, different types of plastics cannot be combined with one another. Another major chemical property handicap in the reuse of plastics is that reprocessing plastics adds a heat history, degrades plastic's chemical properties, and makes repeat use for the same end product difficult. This is why you most regularly see one type of plastic container (a milk jug, for example) being recycled into a different type of product (such as plastic lumber).

The # 1 PETE (or PET, depending on the location) symbol stands for polyethylene terephthalate. Soda bottles, water bottles, vinegar bottles, and medicine containers are typically made from PETE. PETE can be melted and drawn out into long fibers and recycled into carpets, fiberfill for jackets, and fabric for T-shirts and shopping bags (which unfortunately cannot be recycled). Manufacturers want recycled PETE and will buy it. However, very little of the PETE that is recycled is used in the manufacture of new beverage containers (for example, a major cola bottler reports using approximately 3% of recycled PETE in their bottles). This is partly due to the fact that when PETE is broken down, the molecular chains become shorter and weaker.

Milk and water jugs, detergent and soap bottles, buckets, and some toys are made from number # 2 HDPE or high-density polyethylene. Clear HDPE is generally easily recycled; the colored HDPE is generally recycled into plastic lumber and other higher density plastics. There is a definite market for these plastics, as HDPE is very strong—so strong that it is sometimes recycled into products used for synthetic ice (for skating rinks) and bulletproof vests.

In many communities, the only plastic types that are involved in curbside recycling are # 1 PETE and # 2 HDPE. Recycling of all of the following types varies widely depending on the community and markets for the products.

Vinyl or polyvinyl chloride (# 3 V or # 3 PVC) can be recycled. It is used for clear food packaging, plumbing pipe, cooking oil bottles, baby bottle nipples, shrink-wrap, vinyl dashboards and seat covers, and other products. However, collecting it for recycling is cost-prohibitive in many areas because there are not enough items made from the # 3 V to warrant most local factories to recycle it into new products. As a result, much of the # 3 V that is collected for recycling still ends up in a landfill.

Low-density polyethylene (# 4 LDPE) is very flexible and is made into bags for bread, frozen food, and groceries. Some of these bags are recycled into new bags or into plastic lumber. This plastic is lightweight; therefore trucking it back for recycling into the same type of product (such as making grocery bags from grocery bags) requires more energy than producing a virgin product. Unless there is a recycling factory close by that desires the LDPE, most of it collected by curbside recycling ends up in the landfill.

An important chemistry note here: the molecular formulas for # 4 LDPE and # 2 HDPE are the same. The difference in the plastics is the density of the molecular chains. In HDPE the chain is essentially one long continuous chain that allows the strands to fold back upon one another neatly and densely occupy space. In LDPE, the chains have multiple branches that prevent neat stacking, and therefore the chains and branches occupy more space and result in a lower density.

Polypropylene (# 5 PP) is made into containers for yogurt, margarine, and other foods. Like # 3 V, in many communities there are not enough containers made from PP to justify collecting it and shipping it to a recycling factory. In places where big industries use PP, however, there is enough volume for it to be sold for recycling rather than sent to a landfill. Also, because # 5 PP is used almost exclusively for food containers, and because food wastes often contaminate recycling machinery, some recycling programs automatically do not recycle # 5 PP because most people do not wash out these containers before they place them in their curbside recycling bins.

No other plastic has been more controversial than # 6 PS, polystyrene. Coffee cups, disposable cutlery and cups (clear and colored), bakery shells, meat trays, "cheap" hubcaps, packing peanuts, and foam insulation are all made from polystyrene. Although polystyrene is 100% recyclable (and it should be noted that for most foam food containers, 95% of the volume of the product is actually air), the cost of moving used foam products is typically greater than manufacturing them from virgin oil. As a result, polystyrene is typically sent straight to landfills. In addition, because it is disposed of as solid waste and is so lightweight that it becomes airborne and then floats on water, polystyrene is often found littering waterways, is mistaken for food by aquatic animals and birds, and is often fatal to them if consumed.

However, there is another side to the polystyrene controversy. Many cities have banned polystyrene for food packaging, believing that by requiring paper products for food packaging they are promoting the use of a biodegradable material that will reduce impact on landfills. In order to evaluate the true impact of polystyrene versus paper food containers, two independent studies were conducted in the early 1990s, with the results confirmed, corroborated, and published in the journal *Science* (Hocking 1991). The summary of these reports follows.

The costs and benefits of using polystyrene for food packaging have to be examined on both the production and disposal sides. An analysis of the production of a single old-fashioned McDonald's polystyrene hamburger shell (cited by Reed 1995) found that the production of the paper equivalent used today requires 70% more energy and creates 54% more air pollution and 58% more water pollution. It is no surprise that the cost of the paper product is also twice that of the polystyrene, by today's prices. On the disposal end, unfortunately, new landfill construction regulations where layers of waste are routinely covered over by soils and not regularly exposed to air means that biodegradable papers in landfills do not always degrade at the rates expected; when they do, they produce methane, carbon dioxide, and many water soluble products (such as cellulose) that create oxygen demand when decomposing.

Hocking's analysis (comparing the impact of a paper versus polystyrene drinking cup) showed that the average 10-gram paper cup consumes 33 grams of wood and uses 28% more petroleum in its manufacture than the entire input of a polystyrene cup. The manufacture of the paper cup also requires 36 times more chemical input (partly because it weighs seven times as much as the polystyrene), 12 times as much steam, 36 times as much electricity, and twice as much cooling water. The production also generates 580 times as much wastewater, 10 to 100 times the residual effluents of pollutants, and three times the air emission pollutants.

Why have some fast food businesses still shifted to paper products even though the evidence suggested staying with polystyrene? Customers trying to be good environmental citizens demanded it. To add to the environmental mistake, their paper products often cannot be recycled anyway, because health regulations demand that the paper be plastic coated.

Does this mean that the proper environmental decision is to use polystyrene? Thomas (2006) states it is not and that instead, the proper environmental solution is to reduce use of any of these products, use washables when possible, and use polystyrene when forced to make a choice.

The last of the labeled plastics is # 7 OTHER. It is referred to sometimes as the "hotdog of plastics" because it is made of any combination of # 1–6 or another less commonly used plastic. As a result, it is virtually nonrecyclable because the cost to separate its chemical components far exceeds the market for the source.

Raising students' awareness of recycling

There are many sources for lesson plans and activities that address recycling. Below are just a few, but all must be examined in light of the local capacity for recycling in your area, the recent facts about recycling (including the polystyrene issues above), and the input and output of all processes considered. Recycling is a topic that most students will be highly interested in because they are likely to be engaged in recycling in their own home (and school), and it is one where you can integrate all of the subject areas (mathematics, language arts, social studies, and science) into a challenging and worthwhile unit of study.

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Thomas, R.A. 2006. Paper or plastic: What's the best choice? *www.loyno.edu/lucec/paper.html*

Resources

Reduce, Reuse, and Recycle—*www.kidzone.ws/plans/view.asp?i=150*

Assorted lesson plan links—*http://aggie-horticulture.tamu.edu/extension/compostfacility/les.htm*

Reduce, reuse, recycle theme page—*www.cln.org/themes/recycle.html*

Education World—*www.education-world.com/a_lesson/lesson308.shtml*

Recycling lesson plan—*http://whyfiles.org/004antarctic/teacher4/recycling.html*

A to Z Teacher Stuff—*www.atozteacherstuff.com/Themes/Recycling*

Discovery Education—*http://school.discovery.com/lessonplans/programs/recycling*