



ACTIVITY ONE: SMOLDERING NASTY STUFF



SUMMARY

Students will learn that burning trash produces dangerous air pollution that harms human health, and that burning trash is illegal. Students will evaluate amounts and types of materials typically discarded, and consider alternatives to disposal.

OBJECTIVES

(7.E.1.6) Conclude that the good health of humans requires: monitoring the atmosphere, maintaining air quality and stewardship.

TIME NEEDED

Preparation: See Appendix One

Pre-Activity Research and Discussion: 30 minutes

Activity Part A: 15 minutes

Activity Part B: 20 minutes

Post-Activity Discussion: 10 minutes (or homework)

A project of the North Carolina Air Awareness Program



“STUDENTS EXAMINE THE EFFECTS OF BURNING HOUSEHOLD TRASH AND EXPLORE ALTERNATIVES TO BURNING.”

SUMMARY

Burning household trash contributes to air, soil, and water pollution, and is illegal in North Carolina. Students will investigate:

- The contents of household trash
- The “ingredients” of common trash items
- The pollution caused by burning trash
- Alternatives to burning proper disposal, recycling, re-use, and composting.

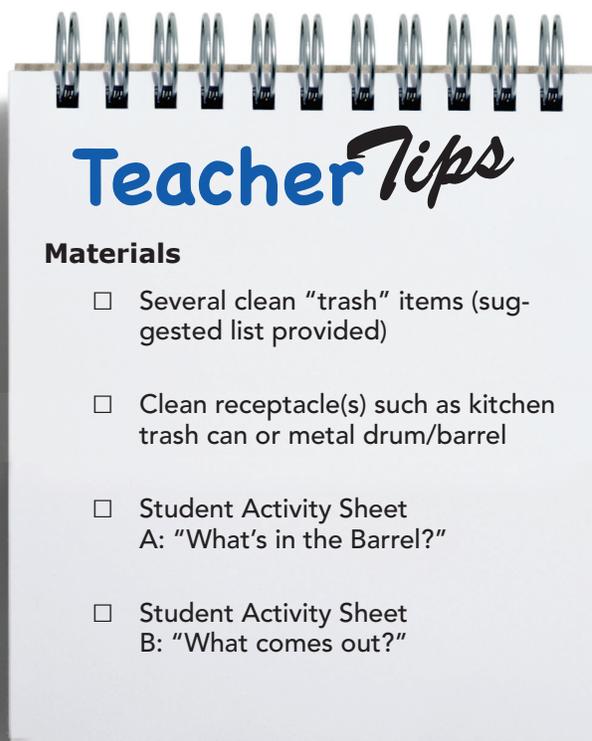
KEY TAKE-AWAYS

- Burning trash and other man-made materials is harmful to human health and the environment, and is illegal.
- We can reduce the human and environmental impact of our trash by generating less waste, re-using and recycling items, and choosing other disposal methods.

COMMON CORE & ESSENTIAL STANDARDS

- 7.E.1.6
- 7.L.2.3
- 7.TT.1
- 7.RP.1
- 7.SI.1
- 7.G.1.1

*Multiple correlations to English LA Common Core requirements



Materials

- Several clean “trash” items (suggested list provided)
- Clean receptacle(s) such as kitchen trash can or metal drum/barrel
- Student Activity Sheet A: “What’s in the Barrel?”
- Student Activity Sheet B: “What comes out?”



BACKGROUND

Each day, every person in the United States creates an average of 4.4 pounds of trash.¹ In many parts of North Carolina and the United States, burning has been the traditional way to get rid of trash. However, burning trash or any other manmade material is illegal in North Carolina.

Burning trash and all other man-made materials outdoors has been prohibited since 1971 under North Carolina's open burning rule, one of North Carolina's oldest air quality regulations. **Open burning** is any type of burning in which the smoke is released directly into the air, without passing through a chimney or smokestack. Examples of open burning include burning trash in a barrel, and burning leaves in a pile. Under the open burning rule, it is always illegal to burn trash and other **non-vegetative** materials. Leaves, branches and other plant growth can be burned only under certain conditions.

Why do people burn trash?

In North Carolina, most residential trash burning (about 90%) happens in rural counties.² In many of these areas, especially outside of city or town limits, trash pick-up is not provided. Households have to hire a private trash hauler, or take their own trash to a landfill, sometimes paying a tipping fee. However, air quality inspectors have noticed that it's not just the cost or inconvenience of proper disposal that causes people to burn their trash. Often, people in rural areas burn their trash because it's the only disposal method they've ever known, and it's the way their families have disposed of trash for generations.



What can and can't be burned legally? A good rule to remember is: **"If it doesn't grow, don't burn it!"** All manmade or non-vegetative materials are illegal to burn in North Carolina. Even lumber is considered a man-made material and cannot be legally burned.

Vegetative material such as leaves, brush, and tree limbs may be legally burned only in areas where public pick-up for these materials is not provided. Even in areas without public pick-up, local laws may restrict or prohibit burning of vegetative material.

In counties with an air quality forecast, all open burning is banned on **Air Quality Action Days**. These are days when the forecasted air quality is Code Orange (unhealthy for sensitive groups), Code Red (unhealthy), or Code Purple (very unhealthy).

What kind of pollution is caused by burning trash, and how is it harmful?

Smoke is a mixture of gases and tiny particles. The gases in smoke, from both vegetative and non-vegetative materials, include carbon monoxide, carbon dioxide, nitrogen oxides (NOx), and volatile organic compounds (VOCs). Household trash typically contains plastics, chemically treated paper, and other **synthetic** materials that, when burned, emit toxic chemicals into the air. These chemicals can include dioxins, furans, hexachlorobenzene, lead, mercury, and many others. The chemicals released by burning trash can harm people when they breathe the smoke, or when they are exposed through contamination of plants, land and water.

Health effects from breathing smoke: The health effects of breathing smoke can include lung and eye irritation, coughing, headaches, dizziness, asthma attacks, heart attacks, and even death. Exposure to smoke from burning trash could have long-term consequences, as some of the toxic chemicals are probable or known human carcinogens and have other health effects.



The tiny particles in smoke are called **particulate matter or particle pollution**. These particles, whether from burning natural or synthetic materials, travel deep into the lungs and can cause serious respiratory and heart problems. While breathing particle pollution is harmful to everyone, it is especially dangerous for people with existing respiratory disease like asthma or emphysema, or existing heart problems. Breathing particle pollution can cause asthma attacks and acute bronchitis, and may increase the risk of respiratory infections. For people with heart disease, the particle pollution in smoke can cause heart attacks and cardiac arrhythmias (irregular heart rhythm). Numerous studies have linked elevated particle levels to increased hospital admissions, emergency room visits, and even death from heart and lung disease.³

Burning trash contributes to regional air pollution. But the greatest impact of burning trash – and even leaves and brush – is to people living nearby, who may be exposed to concentrated smoke and high levels of pollutants. Smoke from burning trash can be a serious health threat for you, your family, and your neighbors, especially for anyone with a respiratory or heart condition.

Health effects from plant, soil and water contamination: Burning household trash is the largest known source of dioxins in the nation.⁴ Dioxins are highly toxic, long-lasting chlorinated organic compounds. They are dangerous even at extremely low levels and have been linked to cancer and developmental and reproductive disorders. Dioxins produced by burning trash settle on plants and into water. Meat and dairy animals eat the plants, and store the dioxins in their fatty tissue. People are exposed to dioxins primarily by eating meat, fish, and dairy products, especially those high in fat.

Smoke from burning synthetic trash deposits other hazardous chemicals like furans, mercury, and hexachlorobenzene onto land and

water. Like dioxins, these chemicals enter the food chain and are ultimately consumed by people. These pollutants can have long-term health effects such as nervous system or organ damage, or reproductive or developmental disorders.⁵

The ash from burning, which is often dumped onto the ground, can contain lead, cadmium, mercury, chromium, arsenic and other toxic substances. These leach into the soil to be taken up by plants (including food plants) and seep into groundwater, or run off into streams, rivers and lakes. Children can accidentally swallow toxic chemicals from dirt on their hands while playing near discarded ash.⁵

What happens to trash when it's burned? Does it all go up in smoke?

The Law of Conservation of Mass states that matter cannot be created or destroyed. When an item is burned, it doesn't just go away. Rather, the item is changed into other substances through the process of **combustion**. Combustion is a chemical reaction between a fuel and oxygen that gives off heat. When the fuel is ignited,



oxygen combines with the chemical components of the fuel, converting them into different combustion products. In general, when the reaction uses more oxygen, it reaches a higher temperature and the fuel undergoes more complete combustion, meaning greater oxidation of the fuel's components.



When trash is burned in a pile or burn barrel, the fire doesn't get much oxygen and burns at a relatively low temperature, resulting in **incomplete combustion**, which produces more smoke and toxic emissions. For example, dioxins are produced by burning items that contain even tiny amounts of chlorine, and nearly all household waste contains chlorine. The relatively low combustion temperatures of burn barrels produce significant amounts of dioxins, whereas very high temperatures such as those reached by waste incinerators (typically over 2,000 degrees F) destroy dioxins by converting them into other compounds which can then be captured by pollution control equipment.

What are alternatives to burning?

REDUCE: the amount of trash you make. Try to buy products that use less packaging. Containers and packaging make up the largest portion (30%) of trash generated by Americans.¹ Carry re-usable bags when shopping. Store food in re-usable containers (for example, pack sandwiches in re-usable containers instead of foil or plastic bags).

RE-USE: Use plastic yogurt tubs (and other containers) to store food or other items. Use old newspapers as mulch (but not the glossy inserts, because those inks can contain heavy metals).

RECYCLE: Even if your community doesn't have curbside pickup, recycling stations may exist at your local landfill and other locations. Some recyclable items, such as plastic bottles, are banned from North Carolina landfills. Many North Carolina businesses process recycled items or manufacture new items from them, so when you recycle,



you support these businesses by providing them with "raw material." Visit <http://p2pays.org/localgov/ncwaste.html> to find recycling contact information for your community.

COMPOST: Let nature turn your leaves, grass clippings, and small branches into wonderful mulch. Not sure how? Visit www.p2pays.org/compost/ for a "Composting 101."

PROPERLY DISPOSE

of the rest. Some stuff has to be thrown away. Materials such as solvents, pesticides, oil-based paints, and many other chemicals should be taken to a hazardous waste facility. You can find information on disposal facilities in your area at <http://p2pays.org/localgov/ncwaste.html>. Some materials, such as computer equipment and mercury-containing thermostats, are banned from North Carolina landfills. For more information on banned materials and how to dispose of or recycle them, visit <http://ncdenr.org/web/deao/recycling/banned-materials>.

Is open burning ever good? Forestry and wildlife agencies sometimes set **prescribed burns** to keep forests healthy. This is open burning on a large scale and while it does produce pollution, it is essential to the health of **fire-dependent ecosystems** such as the longleaf pine forest of the North Carolina Sandhills region. In fact, species such as the red-cockaded woodpecker, the St. Francis' sally butterfly, and the longleaf pine itself depend on regular burning for the species to survive. Prescribed burns should only be set by forestry and wildlife professionals, who are trained in fire safety and management.



PREPARING FOR THE ACTIVITY

1. Gather clean “trash” and at least one container to represent a burn barrel, as described in Appendix One on page 8. Be sure to follow the safety precautions listed.
2. Print activity sheets A and B for each student.
3. Decide if you want students to complete Activity Parts A and B in small groups or as a class.

Pre-Activity Part One: Independent Thinking

Prior to the activity, assign student to come up with their own answers to the following questions in small groups, or independently at home. Students should record their answers in their journals or notebooks.

- What is open burning?
- How might it be harmful to humans?
- How might it be harmful to the environment?

Pre-Activity Part Two: Class Discussion

Students share their answers and discuss with the class how open burning and the resulting air pollution might directly and indirectly affect them. As a class, develop a master list and record in notebooks or journals. After initial independent thinking and discussion, groups or students should review printed brochures and materials from the NC Division of Air Quality on open burning to learn the basics. If computer and internet access is available, go to <http://ncdenr.org/web/air/open-burning/education>.

Pre-Activity Part Three: Class Discussion about Burning Trash

- 1) Ask students some of the following questions:
 - How does your family get rid of garbage?
 - How many of you have a burn barrel at home? (Show of hands).

- How many of you have friends or grandparents with a burn barrel or burn pile?
- How many of you help your family or friends burn?
- What have you seen burned in burn barrels or burn piles? (Let students give examples).
- Why do people burn their trash?
- Is burning trash legal in North Carolina?
- How many of you know someone with asthma or another lung disease?
- Are there other possible health effects from breathing the smoke from burning trash that we haven't already discussed? (Heart attacks from particle pollution, cancer from toxic chemicals, etc).
- Discuss background information with students, especially:
 - Although it may be convenient, trash burning produces pollution that can hurt those who burn, their families, and their neighbors.
 - Trash burning is illegal. The purpose of the law is to protect human health and the environment.
 - Trash contains a lot of manmade materials that produce toxic chemicals when burned.

ACTIVITY

Activity Part A: What's In the Barrel?

Have each student select five items from the burn barrel and fill out Activity Sheet A. For each item, the student will itemize the components or ingredients of the items, and consider alternatives to disposal. This will take some guesswork, which is acceptable. The goal is for students to realize that



even a cereal box, for example, contains not just paper but is printed with inks and coated with a varnish.

As the students examine their trash items, have them “discard” the trash items in sorted piles (a single set of piles for the entire class): recyclable, re-usable, compostable, and “has to be thrown away.” Roughly, what fraction or percentage of their “trash” has the class diverted from the landfill or burn barrel? What percentage or fraction of the original “trash” pile really has to be thrown away?

Activity Part B: What Comes Out of the Barrel?

- 1) Inform students that the average American produces 4.4 pounds of trash per day. (Although some of this total is discarded while away from home, for the purposes of this activity we will assume that the entire total is discarded at home).
 - 2) Ask students to guess how many pounds of trash:
 - they personally throw away during a day.
 - their household throws away during a day.
 - their household throws away during a week.
 - 3) Using either the national average of **4.4 pounds/person/day**, OR their own estimates, students will complete Activity Sheet B (“What Comes Out?”) to calculate how much trash their family discards in a week, and what emissions result from burning that trash. (See Appendix Two for more detail on these emission factors).
 - 4) If time allows, select one student’s activity sheet (or ask a student to volunteer). Write the weekly pollutant totals on the board. Ask the students to guess how many households in their community burn trash. Multiply the single-household weekly total on the board by this number to calculate the estimated total weekly emissions for their community. Then multiply this number by 52 to estimate the total yearly emissions from their community.
- ## CLASS DISCUSSION
- If your grandfather burned trash 30 or 40 years ago, would his trash pile have been any different? What about trash that your great-great-grandfather might have burned in the 1920s or earlier? Are there more plastics in today’s trash than in previous decades? Which would probably produce larger amounts of toxic emissions: a burn barrel containing mostly paper and metal, or one containing paper, metal, and large quantities of plastic?
 - Besides plastics, did you come across items that are especially dangerous to burn? (Examples: treated wood contains arsenic, which is emitted during burning. Aerosol cans can explode and the resulting metal shrapnel can injure or kill anyone standing nearby).
 - Even if you’re only burning paper, or even just leaves, is the smoke “safe” for you, your family, and your neighbors? (Answer: No; all smoke can cause respiratory problems and even heart problems. Paper is not just wood, but contains chemicals from the paper manufacturing process, including chlorine which causes dioxin formation).
 - Do individuals and families throw away more trash today than they did 30 years ago? 50 years? 100 years?
 - Is curbside recycling available in your community? What about recycling drop-off sites? What items in the trash piles could be recycled in your community?
 - Are all of your trash items really “trash”? Or are some of them actually valuable resources? What items in your trash pile could be re-made into useful new items?
 - Besides avoiding burning, landfilling or littering, in what ways does recycling these items help the environment?
 - Examples: making aluminum beverage cans from recycled cans uses 95%



less energy than making cans from aluminum ore. This reduces pollution caused by energy production. It also reduces the need to mine aluminum ore (bauxite), which causes environmental damage. Many plastic items can be made into new bottles, toothbrushes, and even clothing. This saves some of the energy used in manufacturing, and also reduces pollution from extracting, transporting and refining petroleum and other raw materials that would otherwise be used to make new products.

For each of these options, consider factors that might affect whether people are likely to use these options, such as convenience (number and location of facilities, driving distance, hours of operation) and cost (tipping fees or other disposal costs).

This information may be available via the internet, or from your town or county solid waste agency.

- 3) Have students track, to the extent practical, what their household throws away over the course of one to three days. Students may create a chart or checklist to post near the "main" trash can in their house (usually in the kitchen).

EXTENSION ACTIVITIES

- 1) Have students interview their parents and grandparents about their family's use of disposable items when they were children and young adults. Ask parents and grandparents if they remember their own parents' and grandparents' use of disposable items. Did households throw away less? Were fewer plastic items used? What about paper towels, plastic storage bags, disposable food storage containers, restaurant take-out containers, packaging, etc.? If fewer of these items were used, what was used instead? (For example, their grandparents may have used a Mason jar or non-disposable dish to store leftovers, rather than a disposable plastic container). In the same interview, students may ask if their parents' parents or grandparents burned trash.
- 2) Have students research what options exist in their community for:
 - o Recycling (what, where?)
 - o Disposing of regular (non-hazardous) trash.
 - o Disposing of hazardous waste (What materials are considered hazardous? Where are disposal facilities?)
 - o Disposing of yard waste, tree limbs, brush, etc.

MORE RESOURCES AND REFERENCES:

Web links and resources are available at:

- o North Carolina Division of Air Quality website: www.ncair.org (look for the "open burning" tab).
- o <http://ncdenr.org/web/air/openburning/resources>



APPENDIX ONE: *BUILDING A BURN BARREL*

You will need:

- One or more containers to represent a burn barrel. You can use a clean trash can (kitchen-type can or larger), or an actual clean drum or barrel if you have access to one (most burn barrels are old 55-gallon oil drums). You can even use a large cardboard box – be creative! If students will be divided into groups, provide a “burn barrel” for each group if possible.
- An assortment of clean garbage items. See below for suggestions. You might:
 - Gather the trash yourself (ask friends and other teachers for donations too!)
 - **With the consent of your administrator**, have students bring trash items from home as a pre-activity assignment.

Whether you or your students collect trash items, make sure to emphasize these safety and hygiene precautions:

- No nails protruding from pieces of lumber
 - No “sharps” (needles), glass, or sharp edges on metal cans
 - Containers, wrappers, and disposable utensils should be thoroughly cleansed of residue and dry. (Damp items may grow mold if stored.)
 - Items such as teabags and paper towels should be unused and dry.
 - No confidential information on receipts or mail
 - No fluid residues in paint cans or glue / caulk tubes (dried residue is fine)
 - And of course, disposable diapers should be unused!
- Assemble trash items into cans/barrels. The lists below offer suggestions for trash mixes. You may assemble separate barrels for residential, construction, and demolition/clean up trash, or you can mix these types. In actual open burning violation investigations, these three types are often found mixed.

Residential:

Cereal box
Bread loaf bag
Newspaper
Disposable diapers
Corrugated boxes
Tea bags

Potato chip bag
Plastic or “play” food,
or pictures of food
(representing real
food)
Magazines

½ gallon milk jug
Soup / vegetable cans
Aluminum drink cans
Junk mail
Shoe box
Alkaline batteries

2-liter soda bottles
Paper towels
Receipts
Gift wrap
Lunchmeat and cheese
packages

Construction:

Plywood scraps
Vinyl siding scraps
Empty paint or adhesive cans
Drink cans / bottles

Treated lumber scraps
Corrugated boxes
Newspaper
Pieces of wire

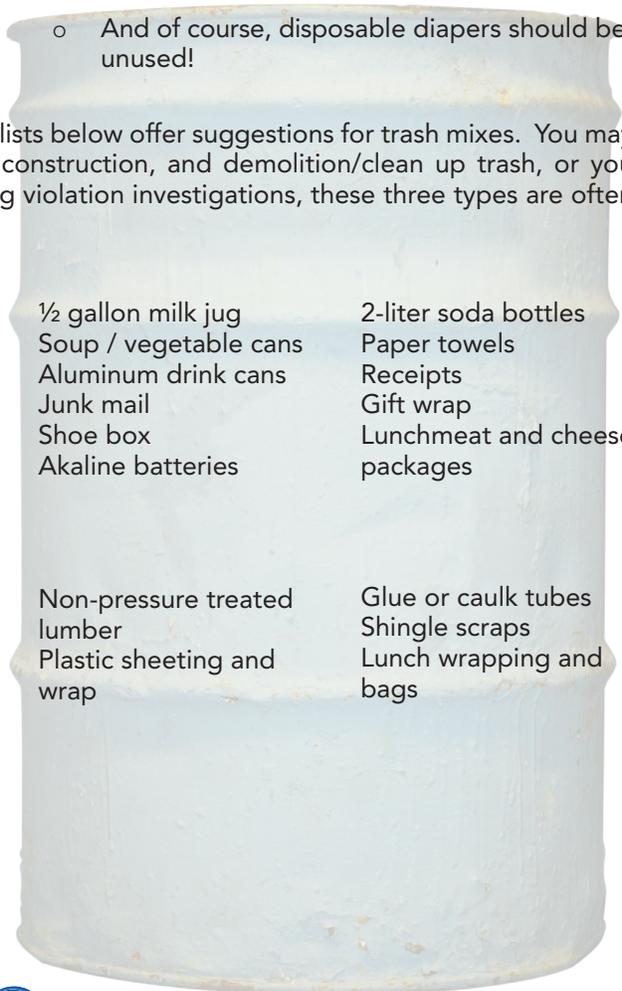
Non-pressure treated
lumber
Plastic sheeting and
wrap

Glue or caulk tubes
Shingle scraps
Lunch wrapping and
bags

Demolition/Clean-up:

Tires (old bicycle/
wheelbarrow tires)
Paint cans
Tables
Old carpet pieces

Chairs
Mattresses
Sofas
Painted lumber





APPENDIX TWO: *NOTES ON EMISSION FACTORS FOR ACTIVITY SHEET B, "WHAT COMES OUT?"*

The emission factors (EFs) used in this worksheet come from the following resource:

U.S. EPA, 2001. Emission Inventory Improvement Program, Technical Report Volume 3: Area Sources; Chapter 16: Open Burning; Table 16.4-1: Emission Factors for Open Burning of Municipal Refuse. This document is found at: http://www.epa.gov/ttn/chief/eip/techreport/volume03/iii16_apr2001.pdf.

The following notes may help the instructor better understand what these factors represent:

PM_{2.5}: This factor represents particulate matter of 2.5 micrometers (microns) or less in diameter. This is the particle size fraction of greatest health concern. These microscopic particles are less than 1/25 the width of a human hair, which is about 70 microns in diameter.

VOCs: These are "reactive" volatile organic compounds that contribute to ground-level ozone formation. The individual VOCs measured and grouped for this EF include 1,3-butadiene, 2-butanone (methyl ethyl ketone), benzene, chloromethane (methyl chloride), ethyl benzene, naphthalene, styrene, and toluene. All of these chemicals are also listed as hazardous (toxic) air pollutants by the U.S. EPA and the N.C. Division of Air Quality: <http://www.epa.gov/ttnatw01/187polls.html>, <http://www.ncair.org/rules/rules/D1104.pdf>.

TOXIC POLLUTANTS: This EF includes factors for the following component chemicals: chlorobenzenes (includes di-, tri-, tetra-, penta-, and hexachlorobenzenes), phenol, total polycyclic aromatic hydrocarbons (PAHs; see EPA 2001 source document for list of component PAHs), total polychlorinated dibenzo-p-dioxins (PCDDs, or dioxins), total polychlorinated dibenzofurans (PCDFs, or furans), total polychlorinated bi-

phenyls (PCBs), hydrogen chloride, and hydrogen cyanide.

Note that all of the VOCs are classified as toxic; however they are listed separately from toxic pollutants because of their potential to contribute to ground-level ozone formation. Therefore students could combine the VOC and toxic pollutant factors for a better estimate of toxic emissions.

No chemicals have been "double counted". If a chemical is included in one EF, it does not appear in another. For example, the EPA 2001 source document includes naphthalene in total PAHs and in VOCs, but for this exercise naphthalene has been removed from the PAH component of the toxic pollutant EF, and appears only in the VOC EF.

WHAT'S MISSING? Burning trash releases emissions of many toxic metals and metalloids into the air. These can include arsenic, cadmium, chromium, lead and mercury, among others. Numerous other toxic chemicals may be emitted beyond those included in the VOC and toxic pollutant EFs. Because reliable emission factors for these emissions have not been identified, those pollutants have not been included in this activity.

EMISSION FACTOR SCALING: The EPA 2001 source document draws emission factors from two resources. EFs for SO₂, CO, CH₄, and NO_x were derived from total refuse weight and have been transferred unaltered to this activity, which estimates emissions based on total refuse weight. EFs for all other emissions were derived from only the refuse that actually burned. Because typically about 20% of refuse is non-combustible (such as metal or glass), these emission factors were multiplied by 80% to scale them more accurately for this activity.