

Paper or Plastic?

A Life Cycle Analysis Perspective

CONTENT AREAS

■ Science

solid waste, energy
resources, air quality

■ Math

data analysis

OBJECTIVES

Students will...

- use the concept of life cycle analysis to make comparisons between different products that have the same use: paper and plastic bags
- use actual data to compare the relative environmental impacts of the two products

MATERIALS

For each student

- Paper or Plastic? Life Cycle Analysis Worksheet
- paper grocery bag
- plastic grocery bag
- Life Cycle Inventory and Poster from Activity 11

TIME

One period
45 minutes

At the supermarket, consumers must decide whether they want their groceries placed in paper bags or plastic bags. Sometimes, consumers bring their own reusable grocery bag. Consumers make choices based on the amount of groceries purchased, convenience, reusability and their perception of the relative environmental impact of these two products.

In this activity, students will analyze the life cycle of each bag to collect data on material composition, energy consumption and waste. For paper bags, the life cycle stages consist of timber harvesting, pulping, paper and bag making, product use and waste disposal. For plastic (polyethylene) bags, the steps involve petroleum or natural gas extraction, ethylene manufacture, ethylene polymerization, bag processing, product use and waste disposal. In all of these steps, energy is required and wastes are generated. When finished, students may have a very different perspective on which product is most efficient, thanks to a variety of source reduction benefits. Only a life cycle analysis can reveal the various factors leading to their decisions.



PROCEDURE

1. Ask students which type of bag they or their families prefer when they go to the supermarket—paper or plastic? Ask them to explain the reasons for their choice.
2. Tell students that they will examine the relative environmental impacts of paper and plastic bags by doing a life cycle analysis. Review the steps a product goes through from “birth to death:” acquisition of raw materials, manufacturing and processing, distribution and transportation, use/reuse, recycling, and disposal. Students will compare energy use, material input, and waste generation in the production, transportation, use, and disposal of these two types of bags.

3. Ask each student to bring one paper and one plastic grocery bag to class. Consider the differences in product use by evaluating paper versus plastic bags according to the following:

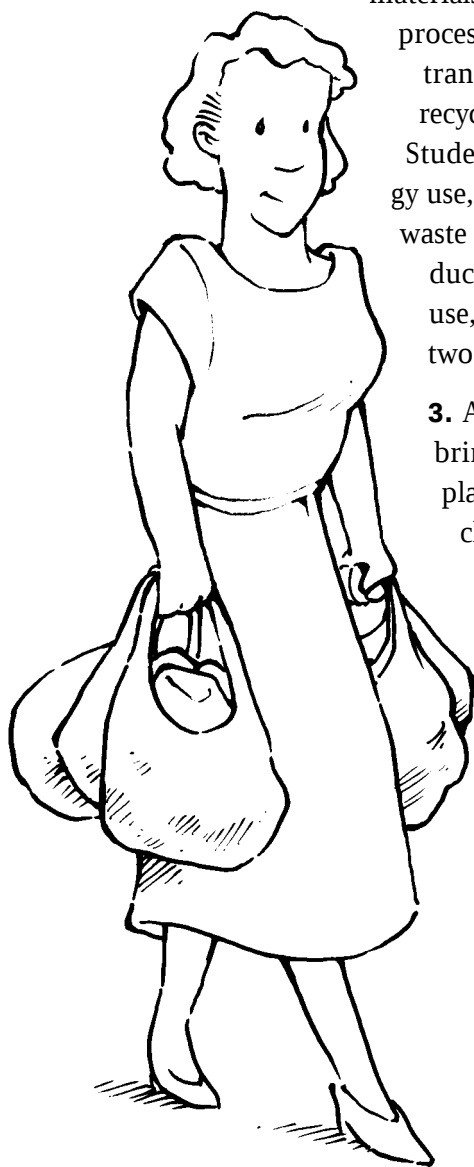
- volume
- strength
- rigidity (stiffness)
- ease of packing groceries
- ease of carrying
- weight

Make a chart on the board to record the students’ answers or have students create a data table to record their answers.

4. Perform the following demonstration to represent to students the amount of space each type of bag might take up in a landfill:

Stack an equal number of plastic and paper bags and compact them by pressing them down. (*To ensure that the compaction is roughly equivalent, select an equal number of books to set on each stack.*) Measure the height of each stack. Ask students to compare the plastic stack with the paper. Which is higher? How much higher? Tell students that 1,000 paper grocery bags stack up to 46 inches, while 1,000 plastic bags stack up to 3.5 inches. (Using the *length x width x height* equation, students can also determine the differences in volume.)

5. Give students a copy of the *Paper or Plastic? Life Cycle Analysis Worksheet*. Have them answer the questions and do the calculations in groups or individually. You may also want to show them the *Life Cycle Inventory* diagram and the poster from Activity 11.



QUESTIONS

When students have completed their worksheets, discuss their answers. Keeping in mind the comparisons for the various life cycle stages, have students analyze their reasons for choosing paper vs. plastic.

- a. Would you make a different choice based on what you now know?
- b. Discuss the importance of looking at all the evidence and not basing our decisions on preconceived notions.
- c. Do you need a bag for every purchase?

Conclude the discussion by exploring how each type of bag can make a significant contribution to source reduction. Because plastic bags are both strong and lightweight, they can do the same job using less material and taking up less space. In addition, the manufacture, use, and disposal of plastic bags creates less impact on our air, land, and water.

Paper bags may take up more space, but they also hold more groceries. In addition, paper bags are made from a renewable resource. (But don't forget that they consume nonrenewable resources in their production.)

EXTENSIONS

1. Discuss the use of cloth or net grocery bags. When are these bags apt to be used? What significant impact would this have on source reduction? What if you used cloth or reusable bags for all of your purchases? How many bags would you save each week?
2. Create a list of multiple ways to reuse plastic and paper bags.

3. Divide the class into two groups. Have each side prepare a persuasive argument why their bag is the better choice.
4. Explore the energy output from incinerating plastic vs. paper bags.

REFERENCES

1. *Resources and Environmental Profile Analysis of Polyethylene and Unbleached Paper Grocery Sacks*, Franklin Associates Ltd., 4121 W. 83rd St. Suite 108, Prairie Village, KS 66208
2. *Issues in Life Cycle Assessment*, Council on Packaging and the Environment, 1255 23rd St., NW, Washington DC 20037-1174



Paper or Plastic? Worksheet



Name _____

ACQUISITION OF RAW MATERIALS, MANUFACTURING AND PROCESSING

To compare plastic and paper bags in terms of acquisition of raw materials, manufacturing and processing, use and disposal, we'll use data provided by Franklin Associates, a nationally known consulting firm whose clients include the U.S. Environmental Protection Agency as well as many companies and industry groups. In 1990, Franklin Associates compared plastic bags to paper bags in terms of their energy and air/water emissions in manufacture, use, and disposal. The following chart is a result of their study:

Life Cycle Stages	Air Emissions (pollutants) oz/bag		Energy Required BTU/bag	
	Paper	Plastic	Paper	Plastic
Materials manufacture, product manufacture, product use	0.0516	0.0146	905	464
Raw materials acquisition, product disposal	0.0510	0.0045	724	185

Raw Materials

a. Which bag would you choose if you were most concerned about air pollution?

b. If we assume that two plastic bags equal one paper bag, does the choice change? (Most shoppers use more plastic than paper bags.)

c. Compare the energy required to produce each bag. Which bag takes less energy to produce?

Distribution and Transportation

Another aspect of life cycle analysis is distribution and transportation. Considering that 1,000 paper grocery bags stack up to 46 inches, while 1,000 plastic bags stack up to 3.5 inches...

a. Which type of bag would require more trucks to transport?

b. How would this affect the amount of gasoline and oil used, and the amount of fuel-related pollutants created for paper bags?

Use and Reuse

As most of us know and practice, plastic and paper bags can be reused and recycled. Reuse and recycling are both important aspects of life cycle assessment.

- a. List the variety of ways plastic bags can be reused.

- b. List the variety of ways paper bags can be reused.

- c. Which type of bag has more uses?

- d. Does your community or local stores accept plastic bags for recycling?

- e. How do you and your community recycle paper bags?

Recycling

It takes energy to recycle paper and plastic bags, and in the process, air pollutants are emitted. Again, the following information is provided by Franklin Associates. It compares the energy required (measured in BTUs) and the pounds of atmospheric pollutants generated when various percentages of paper and plastic bags are recycled.

	0% Recycled 100% Landfilled		50% Recycled 50% Landfilled		100% Recycled 0% Landfilled	
	Plastic	Paper	Plastic	Paper	Plastic	Paper
Number of sacks	60.8	30.4	60.8	30.4	60.8	30.4
Energy required to produce, MM BTUs	39.5	49.5	33.8	38.5	28.2	27.5
Atmospheric pollutants, lbs.	72.6	195.0	64.0	146.0	55.5	98.0

- a. Compare energy per bag and recycling rates. Which bag requires more energy to recycle ?

b. How does the energy comparison between paper and plastic change between the 50 percent and 100 percent recycling rates?

- c. Which bag produces more air pollution during the recycling process?

- d. How does the pollution comparison between paper and plastic change between the 50 percent and 100 percent recycling rates?

- e. How realistic is it to achieve a 100 percent recycling rate?



Disposal

- a. Consider the stacks of paper and plastic bags used for the demonstration, and that 1,000 paper grocery bags stack up to 46 inches, while 1,000 plastic bags stack up to 3.5 inches. Which bag, paper or plastic, takes up less space in a landfill?

- b. Fewer groceries are generally placed in plastic bags compared with paper. If we assume that two plastic bags are generally used in place of one paper bag, which bag would take up less landfill space?

- c. Compare the relative weight of the two stacks. Which stack is heavier? By how much?

- d. Data indicate that 1,000 paper sacks weigh about 140 pounds while the same number of plastic sacks weigh 15.6 pounds. Which kind of bag takes up more landfill space in terms of volume? In terms of weight?

Paper or Plastic? Answer Sheet

ACQUISITION OF RAW MATERIALS, MANUFACTURING AND PROCESSING

To compare plastic and paper bags in terms of acquisition of raw materials, manufacturing and processing, use, and disposal, we'll use data provided by Franklin Associates, a nationally known consulting firm whose clients include the U.S. Environmental Protection Agency as well as many companies and industry groups. In 1990, Franklin Associates compared plastic bags to paper bags in terms of their energy and air/water emissions in manufacture, use, and disposal. The following chart is a result of their study:

Raw Materials

- a. Which bag would you choose if you were most concerned about air pollution?
Plastic
- b. Most shoppers use more plastic than paper bags. If we assume that two plastic bags equal one paper bag, does the choice change? *No*
- c. Compare the energy required to produce each bag. Which bag takes less energy to produce? *Plastic*

Distribution and Transportation

Another aspect of life cycle analysis is distribution and transportation. Considering that 1,000 paper grocery bags stack up to 46 inches, while 1,000 plastic bags stack up to 3.5 inches:

- a. Which type of bag would require more trucks to transport? *Paper*
- b. What implications does this have in terms of gasoline and oil consumption and fuel emissions? *More trucks mean more fuel is consumed and more pollution and emissions are created.*

Use and Reuse

As most of us know, plastic and paper bags can be reused and recycled. Reuse and recycling are both important aspects of life cycle assessment.

- a. List the variety of ways plastic bags can be reused. *Garbage bags, diaper bags, lunch bags, beach bags, rain protection, carry-all, etc.*
- b. List the variety of ways paper bags can be reused. *Garbage bags, lunch bags, recycling bags, etc.*
- c. Which type of bag is the most versatile?
Plastic
- d. Does your community or local stores accept plastic bags for recycling? *About 14,000 stores around the country do.*
- e. How do you and your community recycle paper bags? *The most common way is through newspaper collection. The bags are used to hold the papers or they can be bundled in a bag.*

Paper or Plastic? Answer Sheet, con't.

Recycling

- a.** Compare energy per bag vs. recycling rate. Which bag requires more energy to recycle? *Generally, paper does.*
- b.** How does the energy comparison between paper and plastic change between the 50 percent and 100 percent recycling rates? *Paper becomes slightly more efficient than plastic*
- c.** Which bag produces more air pollution during the recycling process? *Paper*
- d.** How does the pollution comparison between paper and plastic change between the 50 percent and 100 percent recycling rates? *Paper still pollutes more, but the gap vs. plastic is closing.*
- e.** How realistic is it to have a 100 percent recycling rate? *Not very. The costs would be enormous! In fact, very few items without a deposit are recycled at a rate of 50% or above.*

Disposal

- a.** Consider the stacks of paper and plastic bags used for the demonstration, and that 1,000 paper grocery bags stack up to 46 inches, while 1,000 plastic bags stack up to 3.5 inches. Which bag, paper or plastic, takes up less space in a landfill? *Plastic*
- b.** Fewer groceries are generally placed in plastic bags compared with paper. If we assume that two plastic bags are generally used in place of one paper bag, which bag would take up less landfill space? *Plastic*
- c.** Compare the relative weight of the two stacks. Which stack is heavier? By how much? *Paper, by about seven times. See below.*
- d.** Data indicate that 1,000 paper sacks weigh about 140 pounds while the same number of plastic sacks weigh 15.6 pounds. Which kind of bag takes up more landfill space in terms of volume? In terms of weight? *Paper, in both cases*