Polymer Activity from the:

Recycling

Grades: 6-8

Science Standards: Content Standard A: Science as Inquiry; Content Standard B: Physical Science; Content Standard E: Science and Technology

Background:

An average American has over 1300 pounds of trash per year! Up until the late 1800's, Europe and the United States took care of the solid waste problem by dumping, slopping and scavenging. It was not exactly sanitary to have animals eating at food dumps in the streets, and humans scavenging for items to sell among the trash of others. Today there are four ways to handle our solid waste (garbage): 1. Dump it, 2. Burn it, 3. Convert it into something that can be used again, and 4. Minimize the volume of material goods produced in the first place (source reduction).

Ten years ago we had 6000 operating landfills but many are to capacity levels. We have an acute shortage of sanitary landfills at this time. New Jersey has to truck one-half of its household waste to out-of-state landfills up to 500 miles away. Older landfills do not have environmental safe liners of plastic and clay to prevent contamination of ground water supplies. They do not have safe release of methane gas which is created in the decay as waste decomposes. Modern landfills are constructed to include: 1. Clay liners, 2. Polymer liners, 3. Each day's deposit has a layer of soil on top, and 4. Vents for methane gas are installed.

Our national landfill problem has brought plastics to the forefront as an enigma in the packaging world. Plastics deteriorate but never decompose completely, but neither does glass, paper or aluminum. Plastics make up about nine percent of our trash by weight compared to paper which constitutes about thirty-six percent. Rubber, textiles, and leather add an additional five percent by weight. Every year Americans produce 156 million tons of trash. (Derived from "In Defense of Garbage", Judd H. Alexander, Praeger Publishers, c. 1993) Recycling is one alternative so all four of these materials do not end up in a landfill. Currently, legislation is focusing on this alternative and various forms of material collection are being used. Curb side collection has proved most successful over localized drop off sites. Industry is feeling the pressure legislatively as well as economically to use recycled material. Voluntarily, the industry provides recycling codes which appear on the bottom of packaged materials.

PETE, poly(ethylene terephthalate), is commonly used in two liter pop bottles, HDPE, high density polyethylene, in milk jugs, PVC, poly(vinyl chloride), for vegetable oil bottles, LDPE, low density polyethylene, in coffee can lids, PP, polypropylene, in yogurt containers, and PS, polystyrene, in foamed egg cartons or clear bakery trays. (The clear lids will react to heat just as Shrinky Dinks®. Decorate with permanent markers and bake to desired size.) Presently, there are difficulties with recycling plastics after collection regarding separation into various types, soiled materials, and inability to use in food applications. Applications for recycled plastics are growing everyday. Plastics can

be blended into virgin plastic (plastic that has not be processed before) to reduce cost without sacrificing properties. Recycled plastics are used to make polymeric timbers for use in picnic tables, fences, and outdoor toys, thus saving natural lumber. Plastic from two liter bottles is even being spun into fiber for the production of carpet and fiberfill for jackets.

Recycling is a sociological problem too. People who study garbage or solid waste have discovered these truths: 1. People don't recycle as much as they say do (but they recycle just as much as they say their neighbors do), 2. Household patterns of recycling vary over time, and recycling is not yet a consistent habit, 3. High income and education and even a measure of environmental concern do not predict household recycling rates. They have discovered that the price paid for the product will determine how much is recycled. When the prices rise, then the curbside product declines.

A solution for plastics that are not recycled, especially those that are soiled: used microwave food wrap or diapers, can be a Waste to Energy system (WTE). When twenty-eight percent of our trash is packaging material and thirteen percent of that is plastic packaging, an alternative to landfilling needs to be considered for this six million tons of plastic each year. (Derived from "In Defense of Garbage", Judd H. Alexander, Praeger Publishers, c. 1993) Incineration of polymers produces tremendous amounts of heat energy, more than it took to make the plastic originally. The heat energy produced by the burning plastics not only can be converted to electrical energy but helps burn the wet trash that is present. Paper does produce heat when burning but not proportionately as much as polymers. On the other hand, glass and aluminum do not produce any energy when burned. Utmost concern is directed to the incineration process because the by-product carbon dioxide can contribute to the green house effect. There is much debate as to how significant of a concern this is viewing the overall picture compared to the energy produced and the natural resources saved. The greater concern towards burning plastics is the open burning of the material. To better understand the incineration process, consider the smoke coming off a burning object and then ignite the smoke with a Bunsen burner. Observe that the smoke disappears. This is not an illusion, but illustrates the by-products of incomplete burning are still flammable. Incineration burns the material and then the by-products of the initial burning.

A final consideration of the non-degradability of plastics is our country's litter problem. Billions of dollars are spent each year to clean up refuse that is improperly discarded. Wildlife protection groups have challenging arguments against plastics resulting from individuals littering such items as fishing line, and six-pack can holders. The plastic industry remains powerless in regards to preventing people from inappropriately disposing of trash, so they approached the issue from another direction. Plastics are now being made that are degradable due to corn starch additives, or photo degradable additives. Both solutions are assisting in solving the litter problem in spite of the unfortunate actions of the littering population. A basic experiment can be done by exposing samples of food wrap, diaper liners, and trash bags to outdoor light and weather. Squares of plastic wrap can be stretched in small embroidery hoops and then be exposed. Document daily information regarding temperature, precipitation, humidity, the time of sunrise and sunset. Then analyze the materials over a period of a month. It has not been that long since trash bags could be exposed to the elements for years and never decompose.

Sources of Recycled Plastics

PETE

Any soft drink bottle, Spring water bottles such as Evian, Amelia brands, Heinz Ketchup, Gulden's Mustard, container for Penn tennis balls.

HDPE

Gallon and half gallon juice and milk jugs, Dip-It 2 Cleaner, Banquet frozen lasagna, squeeze butter bottles, shampoo bottles, and some bags.

PVC

Peter Pan Peanut Butter jars, Peroxyl mouth rinse, Windex, vitamin bottles, olive oil, "Deli Cat" food containers.

LDPE

French's Mustard, butter dish lids, Maxwell House coffee can lids, lids on microwave foods, dry cleaner bags, many grocery bags.

PP

Nacho squeeze cheese, Breyers and Dannon yogurt containers, Sealtest French Onion Dip, Log Cabin Maple Syrup, spice containers, prescription drug bottles.

PS

Sweetheart plastic cups (colored), styrofoam cups, egg cartons, deli and bakery trays, fast food containers and lids.

Mixed

Del Monte Ketchup, industrial water bottles, Blistex tubes, Ban clear deodorant, some frozen food trays, Lunchables trays.
(NOTE: Manufacturers keep changing their containers so some of these listed may be different when you look.)

Identification of Recyclable Plastics

	PETE	HDPE	PVC	LDPE	PP	PS
Wt.% bottles produced in USA (1989)	25	65	5	1	3	1
Can be Transparent	Yes	No	Yes	No	Yes	Yes
Burns With Matches	Yes Drips	Yes White Smoke Drips	No	Yes White Smoke Drips	Yes White Smoke Drips	Yes Black Particles
Rigidity	Rigid Tough	Semi-rigid	Semi-rigid	Flexible	Semi-rigid	Brittle to Semi-rigid
Bottle Surface	Glossy	Rough	Very Glossy	Low Gloss	Usually Low Gloss	Glossy

Recycled Products

Resin Name	Examples of Recycled Products
PETE or PET	liquid soap bottles, strapping, fiberfill for winter coats, surfboards, paint brushes, fuzz on tennis balls
HDPE	flower pots, drain pipes, signs, stadium seats, trash cans, traffic barriers, toys
PVC or V	floor mats, pipes, hoses, mud flaps
LDPE	garbage can liners, grocery bags
PP	manhole steps, paint buckets, ice scrapers, fast food trays, lawn mower wheels
PS	license plate holders, hanging files, flower pots, trash cans, septic tanks

Sorting Trash!

Purpose:

You are to simulate a recycling plant where the trash is sorted into bins of like materials. You must separate the components of a trash pile by the physical properties of the components. At no time are you allowed to separate items from the trash pile by hand even though most collection centers do separate by hand! A simulated "conveyer belt" will have the trash components on it and you may use this surface to transfer components to other parts of the plant for more separation.

Background:

Physical properties to consider are texture, attraction to a magnet, solubility or how it dissolves in different liquids, strength, and density. Remember density is the ratio of mass to volume and the density of water is about 1 gram/milliliter. Cork is less dense than water so it floats in water. Gravel is more dense than water and it sinks in water.

Materials: (per group of 4)

One bag of trash components:

- 12 pieces of three kinds of plastic (clear soda bottles, butter/margarine lids, and plastic milk jugs)
- 4 glass marbles
- 4 aluminum pie pan pieces
- 4 metal paper clips
- 4 small pieces of wood
- 4 small strips of newspaper

One set of the following "equipment"

- 2 paper towels (These will serve as a "conveyer belt" for the separation of the trash as it moves through the recycling plant. You are allowed to pick up a group of components on the paper towel and place it at a different location in the "plant".)
- 1 magnet
- 1 aluminum screen
- 4-5 straws (DO NOT share these straws.)
- 3 - 400 mL beakers or bowls
- 1 bottle of 70% isopropyl alcohol
- 1 bottle of isopropyl alcohol/ water mixture, tinted blue for identification
- 1 bottle of Karo™ Syrup
- 8 cups for the separated components at the end of lab

Procedure:

As a group, decide how you want to try and separate the trash into its components. Remember that at no time may you use your hands until you have separated the components. Then you may place each in individual cups. There are four of each component in the trash pile and you are to use <u>two</u> of each for testing of physical properties. The last <u>two</u> (clean and dry) will be used in the separation scheme you develop. It might be a good idea to assign tasks to individual members of the team such as a:

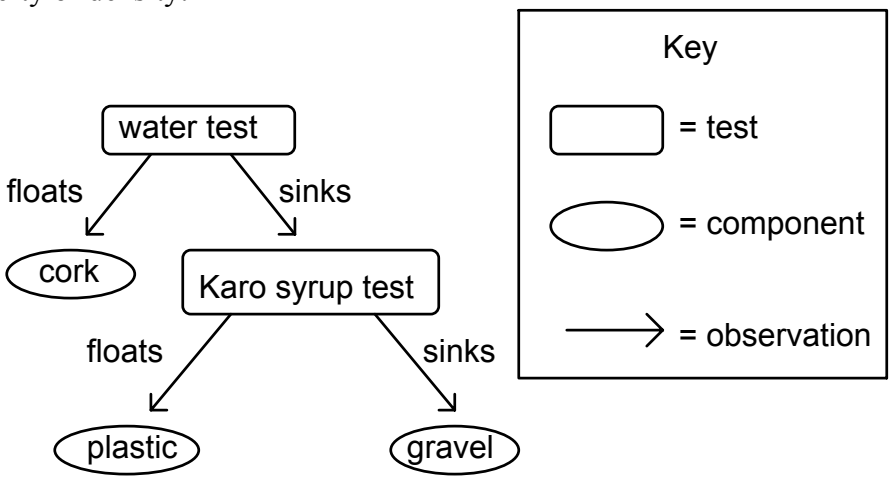
- **Recorder** - of physical properties of components in a data table **and** of the steps for separation or the development of a flow chart of the steps for separation (Flow Chart definition is at the end of this paper.)
- **Process Controller** - watches for the use of hands/ cleaning-up spills/ wise use of equipment/ conveyer belt control, etc.
- **Equipment Manager** - allows only two of each component to be tested for properties and then allows the remaining two for the steps of separation of the trash pile/ operation of the separation techniques/ clean up monitor
- **Reporter** - who is a spokesperson for the group to tell the class how the group solved the problem and to explain the flow chart if there is one

Conclusion:

Each reporter will tell the class how their group solved the problem of separating the trash pile into its components. A discussion, about the processes possible to solve the problem, will be encouraged.

Definition of a flow chart:

This is a diagram to show how one can follow steps of a process in a easy, pictorial manner. For example if one wanted to flow chart the separation of a cork, plastic and gravel using the property of density:



Teacher Notes: Sorting Trash!

The inquiry laboratory is designed to let students make decisions about how they want to solve the problem of separating trash as well as how they want to record their data. A suggested data table is given here if you want your students to have more direction. A flow chart is suggested and encouraged but not required. You may want to spend a few minutes discussing a flow chart and how to read one. Cooperative learning groups with suggested roles for the four students is also encouraged. It might be appropriate to decrease the number of objects to make the exercise easier for some classes.

The materials: (per group of 4)

One bag of the following materials:

- 4 small pieces of #1 polyethylene terephthalate (PET) (from soda bottles)
- 4 small pieces of #2 high density polyethylene (HDPE) (from milk jugs)
- 4 small pieces of #4 low density polyethylene (LDPE) plastic (from lids of butter/margarine containers)
- 4 glass marbles
- 4 aluminum pie pan pieces
- 4 metal paper clips
- 4 small pieces of wood or dowel or wooden splints
- 4 small strips of newspaper

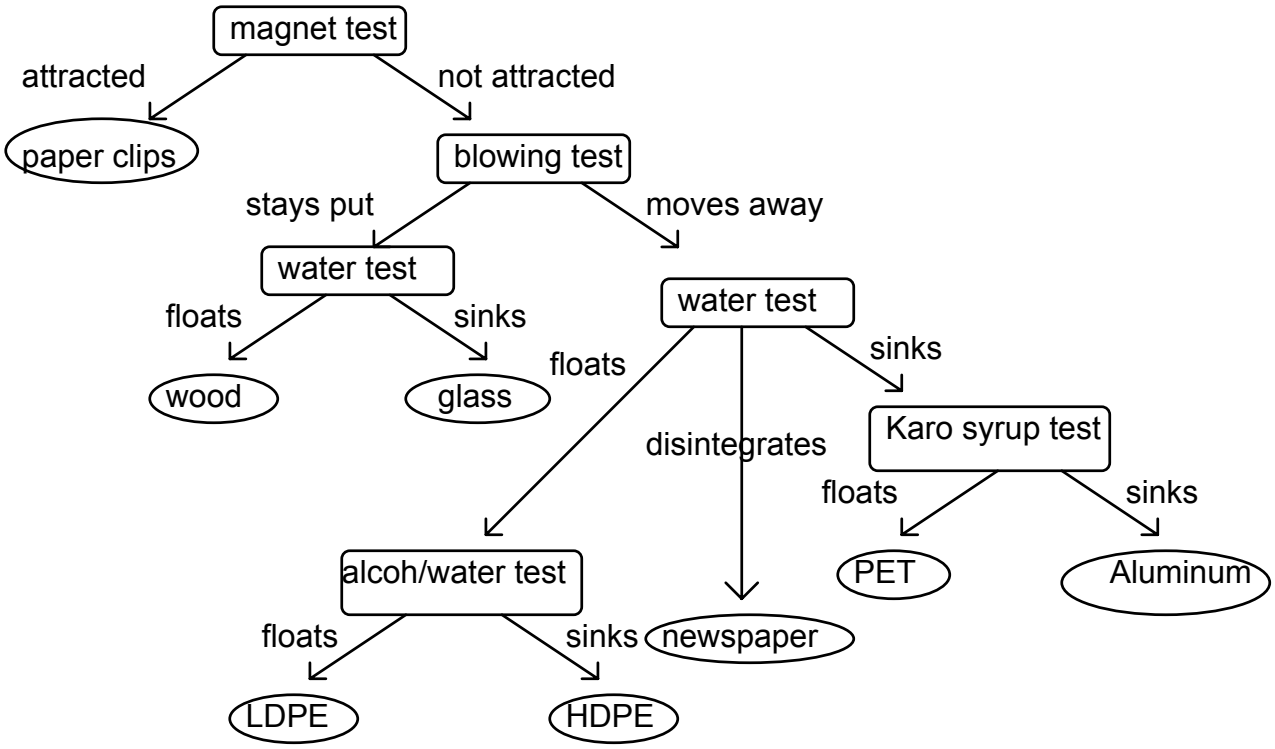
One set of the following "equipment"

- 2 paper towels- (These will serve as a "conveyer belt" for the separation of the trash as it moves through the recycle plant. You are allowed to pick up a group of components on the paper towel and place it at a different location in the "plant".)
- 1 magnet
- 1 aluminum screen - hardware store
- 4-5 straws (DO NOT share these straws.)
- 3 - 400 mL beakers or bowls
- 1 bottle (200 mL) of 70% isopropyl alcohol - drug store
- 1 bottle (200 mL) of isopropyl alcohol/ water mixture, colored blue for easy identification (This is prepared by measuring 60 grams of 70% isopropyl alcohol and adding 40 grams of tap water.)
- 1 bottle (200 mL) of light Karo™ Syrup
- 8 cups for the separated components at the end of lab

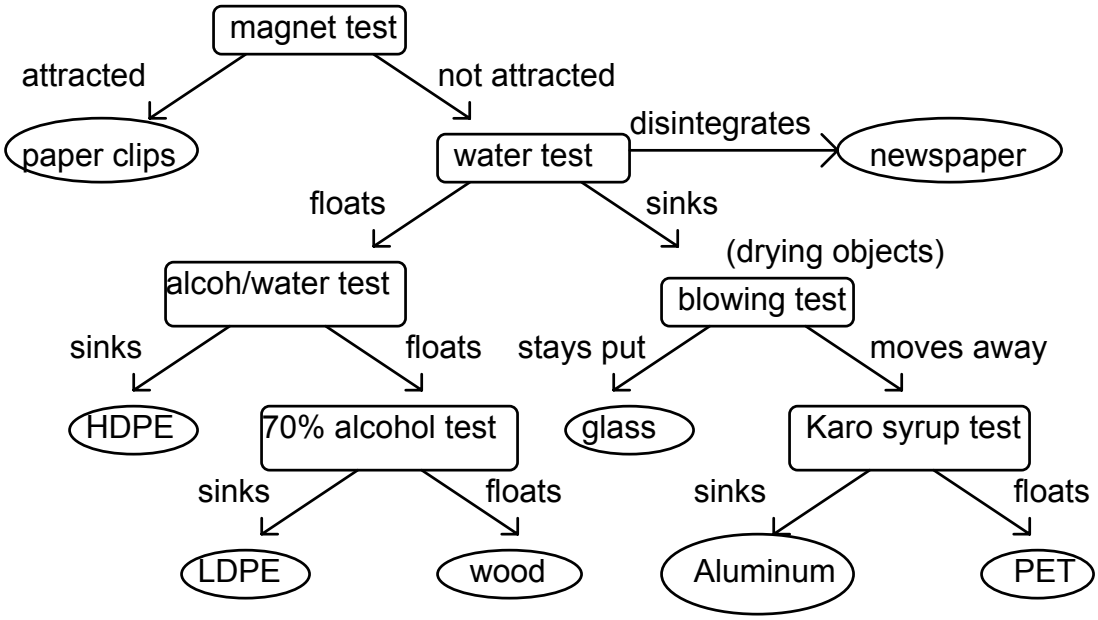
Conclusions:

The following are two ways to separate the trash pile using a flow chart for the explanation:

A.


magnet test
attracted
not attracted
paper clips
blowing test
stays put
moves away
water test
floats
sinks
wood
glass
water test
floats
sinks
disintegrates
Karo syrup test
floats
sinks
PET
Aluminum
alcoh/water test
floats
sinks
newspaper
LDPE
HDPE

B.


magnet test
attracted
not attracted
paper clips
water test
disintegrates
newspaper
floats
sinks
(drying objects)
alcoh/water test
blowing test
sinks
floats
stays put
moves away
HDPE
70% alcohol test
glass
Karo syrup test
sinks
floats
sinks
floats
LDPE
wood
Aluminum
PET

Suggested Data Table format:

Data Table of Properties

Trash	magnet test	blowing test	water test	alcoh/water test	70% alcohol test	Karo syrup test
clear plastic						
lid						
milk jug						
glass						
aluminum						
metal						
wood						
newspaper						

The densities of the components are:

PET	1.38-1.39 g/cm^3
HDPE	0.95-0.97
LDPE	0.92-0.94
glass (SiO_2)	2.20
aluminum	2.7
steel (Fe)	7.85-7.88
newsprint	?

A set of eight videotapes and teacher's guides (aimed at middle school audiences) is available from "Transformations" (1991) for $75.00 plus $5.00 postage and handling. Their address is: Transformations, PO Box 1205, Boston, MA 02130. Call for more information: 1-800-433-AIME. The set includes several topics that are all STS issues and one of which is "Recycling". In this video, students can see an automated recycling plant in operation. Trash composed of glass, food cans, aluminum cans, and plastic are piled onto a conveyor belt and the first separation is with a large magnet that sweeps the steel cans off the belt. A shaker table sorts by size and then an inclined sorting machine separates the glass from the plastic and aluminum by density. Then the trash is exposed to an eddy current magnet and the aluminum cans are hurled toward the magnet to be crushed and thrown into an awaiting bin. Finally the plastics (PET and HDPE) are sorted by hand. There is a machine that can do this process but it is very expensive.

Another excellent video which is <u>free</u> is "Not Your Average Field Trip" by the Society of Plastics Engineers, Inc. The next page has the order form and duplication agreement. **Send the order to: Video Outreach, P.O.Box 12057, Hauppauge, NY 11788-9705**

Written by Mary Harris, Missouri Polymer Ambassador