Polymers in our Waters

Marine Debris and Plastics

Grade Level: 5 – 12

Activity Duration: Varies; multiple class periods

Summary: Though most studies of plastic in the water is done in a marine setting, fresh water and the organisms that live there are at risk from plastic litter in the water. Plastics have different densities and can be found in varying sizes throughout the water column. Aquatic animals may be more likely to encounter some types of plastics than others.

Topic: plastic debris

Theme: Freshwater ecosystems are at risk from plastic litter in the water.

Goals: Student will conduct experiments to determine the buoyancy of common plastics, and to observe the process of plastic degradation.

Objectives:
1. Students will identify what types of plastic will sink and float in freshwater.
2. Students will describe potential interactions of animals in Lake Superior with plastics in the water column.
3. Student will identify ways to reduce plastic consumption.
4. Students will cooperate to complete a clean-up exercise

Suggested Minnesota Science Standards
K-5th grade
0.4.1.1.3, 1.1.1.1.1,1.1.3.1.1, 2.1.1.2.1, 2.1.2.2.2, 2.1.2.2.3, 2.2.1.1.1, 3.1.1.2.3, 3.1.1.2.4, 4.1.2.1.1, 4.1.2.2.1, 4.1.2.2.2, 4.1.2.2.3, 5.4.2.1.2, 5.4.4.1.1

Grades 6 – 12
6.1.2.1.1, 6.1.2.1.2, 6.1.2.1.3, 6.1.2.1.4, 7.4.4.1.2, 8.1.3.3.3, 8.3.4.1.2, 9.1.2.1.1, 9.1.2.1.2, 9.2.4.1.2,

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Background:

A plastic for everyone

The precursor to modern plastics was first created by Alexander Parks in 1862. Since then, and especially since the 1950's, the production and use of plastic for everyday materials has grown dramatically.

Plastics are long chain molecules call polymers. They are typically made from non-renewable resources such as fossil fuels, and can contain a variety of chemical additives us as bishphenol-A, BPA, and phthalates. Plastic is an incredibly versatile material and has seemingly infinite applications, form contact lenses, to computers, food containers and safety equipment. It is relativity inexpensive to make and is very durable. Due to this durable nature, it doesn't biodegrade. Plastic objects themselves may break into smaller and smaller pieces. However, each individual molecule must biodegrade for plastic to break down completely, which potentially can take hundreds of years. We don't know yet the full implications of how long plastic will take to break down. Most if not all plastic molecules ever created are still in existence today.

Plastic in the oceans

Since plastic breaks apart, but does not biodegrade, plastic litter is a real problem. One of the most persistent problems is plastic in the oceans. It's estimated that 90% of all debris floating in the ocean is plastic. The size of plastic pieces varies greatly from intact containers to planktonic pieces, seen only under a microscope.

Plastic in the water is a danger to animals in several ways. Animals can become trapped or entangled in objects and 'ghost' or lost fishing equipment, causing injury or death. Consumption of plastics is another serious risk to both marine and freshwater animals. Many seabirds, including Albatross, are known to consume plastic and also fee plastic to their chicks. Plastics soak up toxins, such as DDT and PCB's that are banned in the US but still persist in ocean waters. Those toxins can be released into the animal once consumed. Birds and other animals are at risk of starvations by eating plastics with no nutritional value, instead of their natural diet.

Plastics have heavy economic impact. Floating debris fouls boat props, come entangled in fishing gear, and clean-up of beaches can be very costly. Not to mention the damage to aesthetic value of shorelines.

Plastic in the Great Lakes

The great lakes is the world's largest freshwater system. Yet, little research has been done to explore the impact of plastics to the same extent they have been studied in the oceans. All around the great lakes, litter as well as mishandled industrial plastic resin pellets are a problem. Organisms are still at risk, and there are costal groups that have tremendous volunteer efforts to collect and record litter and debris. More research is underway to help us realize what the implications of plastics in the waters of Lake Superior might have on the ecosystem.

Teaching students about big issues

"What's important is that children have an opportunity to bond with the natural world, to learn to love it, before being asked to heal its wounds." Nick Sobel, Beyond Ecophobia

Plastic debris in the ocean is a large scale problem. Presenting a topic that appears large and hopeless, can make students feel small and helpless. To ensure that you are teaching in a way that can inform and empower your students we suggest allowing students to lead discussions with their own observations of the world. For example, begin by asking students "What is litter?" and follow up each round of responses to each getting a little more specific each time. "Have you seen litter?" "Where did you see it?" "How do you think it got there?" "What do you think about it?" This challenges them to draw from their own experiences, connecting them in a meaningful way to a topic with worldwide implications. "What can we do about this at our school, and in our community?" Also encouraging students to find realistic ways to contribute to solutions, in this case, recycling and reusing plastic, allows student to take ownership in a positive way.

Procedure:

PART 1: Plastics in the water column

Adapted for freshwater from:
http://www.montereybayaquarium.org/PDF_files/teaching_activities/Plastics_in_theWater_Column6-8.pdf

There are many different plastics created for a variety of uses. Some of them float in the water, some sink and some maintain a neutral buoyancy. A sink or float experiment is a way to introduce the idea of plastic density and how plastics may be distributed in a freshwater environment.

Sink or Float?

Materials: Large clear container for water – must be deep enough to full submerge each object, a collection clean plastic from a recycling bin – be sure to include some that will sink and float. *You may obtain a set of materials for each group (preferred), or one set for class demonstration.*

Directions:

1. Provide each student with a copy of the **Plastics in Our Water** worksheet and each group a set of materials for the sink or float experiment. Have students locate the recycling number on each plastic item.

2. Students will record predictions for each item, whether it will sink or float.

3. To determine if an item will sink or float, have students completely submerge and object and release it. If not completely submerged, surface tension may artificially show an item to float. Students will record the results for each plastic.

4. Have each group come up with a hypothesis why the plastics have different buoyancy.

Some plastics are denser than water so they sink; some are less dense than water so they float. Density is the mass of an object divided by its volume.

5. Give each group a **Density Table** and have students complete **Plastics in Our Water** worksheet.

Plastics in the Lake Superior Food chain

There have been many studies addressing the impacts of plastics in marine animals. For most animals, everything in their habitat could be considered 'edible' whether or not it is a part of their diet. Plastic can break down into smaller pieces and appear similar to prey items and food. Aquatic animals in both marine and freshwater systems, such as the Great Lakes, are at risk of encountering plastic debris.

Copy enough **Lake Superior Feeder Cards** for the class

1. Ask the students where they think the animals live in Lake Superior.

2. Introduce the concept of feeding zones in the water column.

Surface – top of the water column
Pelagic – not the surface or the bottom, open water in the middle
Benthic – bottom of the lake

3. Provide each student with a **Lake Superior Feeder** card. Then either project an image of the **Lake Superior Water Column** or recreate it by drawing on board. Challenge students to think about what plastics would be most likely to be found in each feeding zone, based on the buoyancy experiment they completed earlier.

4. Have students share their animal and what plastics could potentially impact their animal.

5. Brainstorm what impacts plastics have on the freshwater ecosystem. Be sure to introduce the concept that plastics range in size form microscopic, to whole containers.

Plastic debris can cause harm through entanglement, but also as it enters the food web. Plastic pellets have been shown to soak up organic pollutants, such as PCB's from water, and when consumed, can transfer those toxins to the tissue of fish. Organisms that consume plastic instead of their intended food can become sick or die. Predatory animals can be indirectly affected by eating prey animals that have consumed plastics.

6. There have been many studies looking at plastic debris and the impact on wildlife, in a marine setting. Relatively little has been explored regarding plastics in our freshwater systems. As a class, discuss what potential differences there might be between plastic debris in marine waters and Lake Superior (and other Great Lakes).

7. How can we lessen the impact of plastic materials in our fresh and ocean waters? Encourage students to brainstorm products that are made of plastic that we use every day. Can other materials we used instead? Not always.

What are some ways plastic can be beneficial? Contact lenses, medical supplies, safety devices (such as bike helmets), and more

What are the downsides to using so much plastic? It doesn't isn't likely to biodegrade within any of our lifetimes, production requires the use on non-renewable fossil fuels, and disposal is a big problem.

There are many ways we can reduce our consumption of plastic. Have each group create a list or poster of ways we can reduce our one time use of plastic materials. Ideas may include: reusable shopping bags; stainless steel or BPA free water bottles; using refillable coffee and beverage cups on the go; bring your own take out containers, instead of accepting Styrofoam ones.

Extension: Plastic Debris Identification Lab provided by Dr. Lorena Rios UW-Superior

Plastic Debris Identification

Introduction:

Plastics are primary synthetic organic polymers derived from petroleum. They are not biodegradable in any practical human scale of time. The physical characteristics of most plastics show high resistance to aging, they just photodegrade when are exposed to UV radiation in sunlight. Plastics are excellent materials that help us with almost everything that we use in our modern society. These synthetic polymers are used in nearly everything and are used by everybody. The technology to make different kinds of plastic is really very good, but now we have a new problem: Plastics.

Plastic materials comprise one of the most persistent macroscopic pollutants in oceanic waters and beaches in the world. There are many published reports about plastic debris found throughout the world's oceans.

Thermoplastic resin pellets are raw plastic material that are melted and formed into an enormous number of inexpensive consumer goods, many of which are discarded after a relatively short period of use, dropped haphazardly onto watersheds and make their way to the rivers, ocean, and lakes where some get ingested by aquatic organisms. One pound of the most common pellets costs about $1US and contains approximately 25,000 pellets. Between 1960 and 2000 the world production of resin pellets increased 25 fold. Small pieces of polymer (less than 5 mm in size) can be ingested mistakenly because of their size and color, by sea organisms and seabirds for living prey. Forty-four percent of all seabird species ingest floating plastic while feeding on or near the surface of the ocean, picking up anything that might resemble their natural food.

The SPI (Society of Plastic Industry) introduce the RIC (Resin Identification Code) system in 1988 with the objective to provide a uniform system that can apply to all the recycling programs. However, the resin code (RIC) is used just to identify the kind of resin plastic used to manufacture a final plastic product. There are six resin that are used in most of the plastic package: PET or PETE (polyethylene terephthalate); HDPE (high density polyethylene); LDPE (low density polyethylene); PVC (polyvinyl chloride); PP (polypropylene); and PS (polystyrene). The seventh code is used as “other,” this means other resin plastic different to the six resin listed above. The code is imprinted on the bottom of the most of plastic containers. Density is one physical property that can use to distinguish each of these plastics. The analysis of plastics can start with water, the plastics more dense that water will sink and the lower dense than water will float. After this separation the process is repeated with liquids with different densities. In July 2011, 39 states including Wisconsin are using this RIC (in containers of 8 oz or more).

Objective:

Identify the kind of synthetic organic polymer (plastic) by measuring their physical and chemical properties. Learn about “Plastic Resin Identification Code”

Reactants:

1) Alcohol isopropyl
2) Acetone
3) Oil (corn)
4) Resin virgin pellets

Procedure (Follow the chart):

1) Test density of plastic samples:
    a. Water test (float or sink)
    b. Isopropyl
    c. Oil test
2) Acetone test

NOTE: *Do not throw away any plastic pellets*

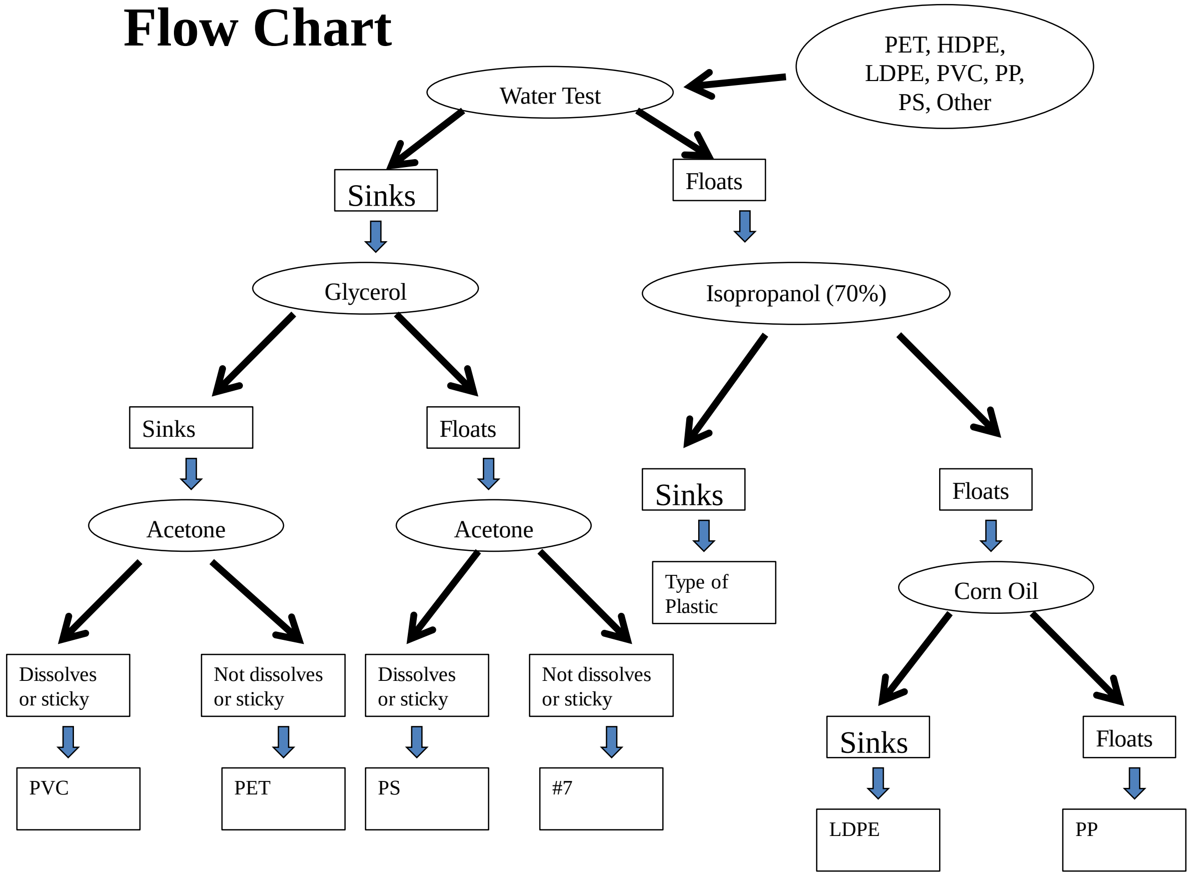
References: read the next papers:

1. Moore, Charles James, 2008. Synthetic polymers in the marine environment: A rapidly increasing, long-term threat. Environmental Research 108 (2008) 131–139.
2. Rios, M L., Jones, P. R., Moore, C., and Narayan, U. V. 2010. Quantitation of Persistent Organic Pollutants Adsorbed on Plastic Debris from the Northern Pacific Gyre’s “eastern garbage Patch.” J. Environ. Monit. 12, 226-2236.

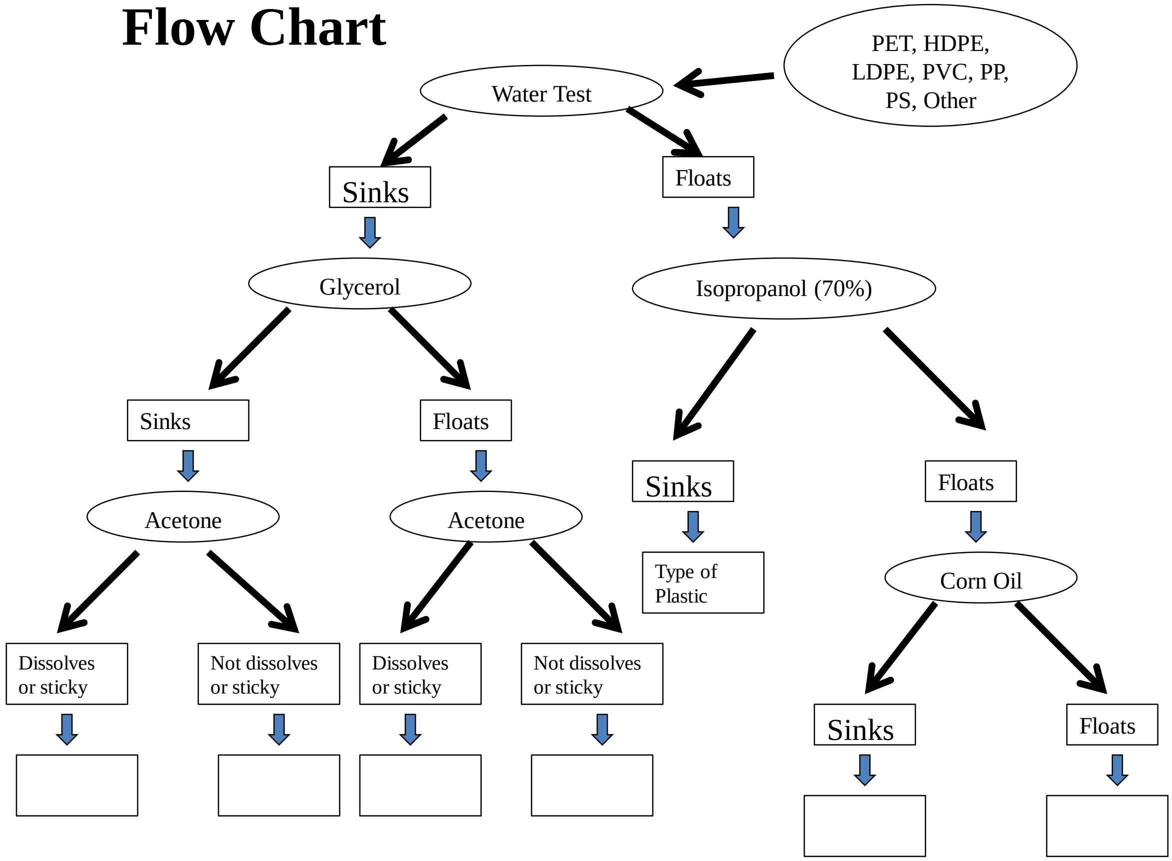
Table1. Density of Plastic Pellets

Plastic	Name	Density (g/mL)
HDPE	High Density Polyethylene	0.95-0.97
LDPE	Low Density Polyethylene	0.92-0.94
Teflon	polytetrafluoroethylene	2.2
PMA	Polymethylmethacrylate(Plexiglas)	1.24
PS	Polystyrene	1.05-1.07
TPX	Poly-4-methyl-1-pentene	0.83
PETE	Polyethylene Terephthalate	1.39
PVC	Polyvinyl chloride	1.16 – 1.35
PP	Polypropylene	0.90-0.91
ABS	Acrylonitrile Butadiene Styrene	1.15
Nylon 6	polyamide 6, Nylon	1.25
Nylon 66	Polyamide 66 nylon	1.13-1.16

Flow Chart


PET, HDPE, LDPE, PVC, PP, PS, Other
Water Test
Sinks
Floats
Glycerol
Isopropanol (70%)
Sinks
Floats
Sinks
Floats
Acetone
Acetone
Type of Plastic
Corn Oil
Dissolves or sticky
Not dissolves or sticky
Dissolves or sticky
Not dissolves or sticky
Sinks
Floats
PVC
PET
PS
#7
LDPE
PP

Flow Chart


PET, HDPE, LDPE, PVC, PP, PS, Other
Water Test
Sinks
Floats
Glycerol
Isopropanol (70%)
Sinks
Floats
Sinks
Floats
Acetone
Acetone
Type of Plastic
Corn Oil
Dissolves or sticky
Not dissolves or sticky
Dissolves or sticky
Not dissolves or sticky
Sinks
Floats

PART 2: Plastic bag degradation

Materials: Fish bowl; Water; Windowsill; Plastic items (fishing line, plastic bag, Styrofoam, etc.); Stirring rod; Magnetic stirring rod (optional); Magnetic stirring plate (optional); Microscope (optional)

Directions: Place plastic items in fishbowl and fill with water. Place fishbowl on a well-lit windowsill. Leave fish bowl for entire semester, year, or as long as you like; stir the water occasionally with a stirring rod, or use a magnetic stirrer to create a constant current. If a microscope is available, sample the water intermittently and examine under the microscope.

Discussion:
How did the plastic degrade in warm, sunlit water?
What broke down first? How long did items take to break down?
Did anything ever completely degrade?
How small did the plastic pieces get in the microscope?
What would be different in nature that would affect the degradation of plastic?
What can we use in place of plastic in our daily lives that degrades more readily than plastic?

PART 3: Cooperative clean up

Materials: A map of lake Superior (large floor map optional); removal equipment – tubing and string; bottles cans and other 'litter'

The Cooperative Clean-up Lesson is included in this kit. For the full Lake Effects Curriculum Guide and other lesson plans, please visit:
http://www.glaquarium.org/education-programs/curriculum/