2008 NATIONAL YOUTH SCIENCE DAY

4-H National Science Experiment

Expanded Student Version

Helpful HYDROGELS

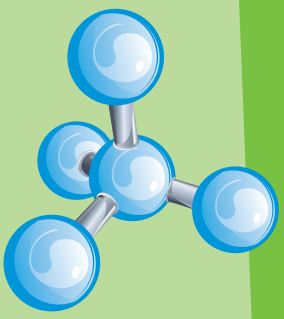
BACKGROUND

Can hydrogels help the environment?

Water is everywhere – in the sky, in the ground, and in our homes. However, caring for this vital resource is often a challenge for each of us. Conservation means using water wisely. Protecting our groundwater is important because it is a source for drinking and irrigation. Consequently, scientists and engineers have developed amazing, superabsorbent polymers, called **hydrogels,** that can help.

In this series of investigations, you will start by looking for a particular polymer at work. Once you discover what this type of polymer can do, you will experiment with other uses for the same polymer. A final step can be taken to consider solutions for water conservation and groundwater contamination.

*A **polymer** is a long chain of molecules. Polymers are all around us, and they make up materials like bicycle helmets, CDs, tires, plastic water bottles, rubber bands, and glue. This experiment focuses on special kinds of polymers that are superabsorbent: hydrogel polymers. Hydrogel polymers are long molecule chains that grab onto water molecules. Some can soak up as much as 500 times their weight in water! This superabsorbent characteristic makes hydrogel polymers useful in water conservation and in solving other environmental issues.*



ENGAGE

Where are the polymers? Why are they there?

PREPARATION

Materials:

- Disposable diaper
- Water
- Newspaper
- Scissors
- Measuring cup and measuring spoons
- Zipper-lock bag; 1 gallon size
- 9 oz. plastic cup

A hydrogel is a class of polymer with some unique characteristics. Find the hydrogel polymer in a diaper and examine its use.

Collect a sample of hydrogel from the cotton and plastic lining of a disposable diaper.

1. Place a new diaper on the piece of newspaper. Carefully cut through the inside lining and remove all the cotton-like material. Put all the stuffing material and plastic lining into a clean, 1 gallon zipper-lock bag.

2. Scoop up any of the powdery material that may have spilled onto the paper and pour it into the bag with the stuffing. Blow a little air into the bag to make it puff up like a pillow, then seal the bag.

3. Shake the bag for a few minutes to remove the powdery hydrogel polymer from the stuffing. Notice how much powder falls to the bottom of the bag.

4. Carefully remove the stuffing and the plastic lining from the bag, and check out the powdery polymer left in the bag. Repeat steps 1-4 with another diaper, if needed, to get 1 tablespoon of the hydrogel powder.

5. Now it's time to mix the powder with water to see what happens. Pour 1 tablespoon of hydrogel powder into a 9 oz. plastic cup. Measure ½ cup of water and pour it into the cup along with the powder.

6. After about 30 seconds, observe that the water has changed — it's no longer a liquid… it's a gooey solid!

Take a closer look at the gel by scooping up some of the gel with your fingers. You can poke holes in it and even tear it into smaller pieces. This hydrogel is safe and non-toxic, so you can touch it, but remember: even safe chemicals never go into your mouth, ears, or nose!

THINGS TO THINK ABOUT...

- How does this water-slurping powder work? Does it only absorb water?
- How much water will the average diaper absorb?
- What would happen if you let the gel dry out? Is this powder reusable?
- Besides diapers, how else could this powder be used?
- How does the absorbency of the hydrogel compare with other materials that are absorbent: cotton balls, paper towels, sponges?
- How could adding other ingredients (like salt) affect a hydrogel's water-absorbing properties?

EXPLORE

Can hydrogels help improve the environment?

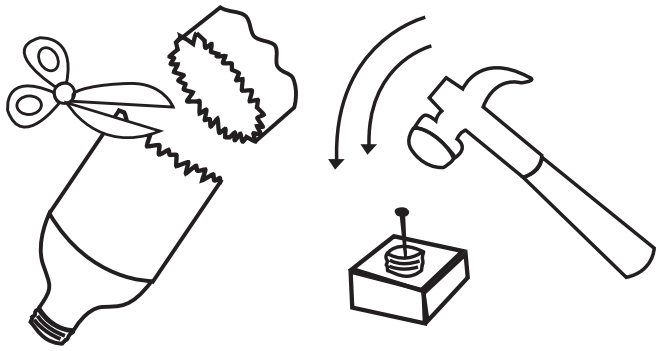
As you discovered, a hydrogel is a **superabsorbent polymer**—which can hold up to 500 times its own weight in water. Could hydrogels be used to address water conservation and groundwater contamination? Create an experiment that tests how hydrogels could work in soil.

Materials for one experiment:

- Hydrogel powder (from disposable diapers)
- Gallon-size, plastic, zipper-lock bag
- 2, 12 oz clear plastic bottles with screw-on caps
- 2 cups packaged potting soil (it is better NOT to use the "moisture control" type)
- Measuring spoon
- Measuring cup
- 1 packet (0.22 oz./6.2 grams) of unsweetened powdered drink mix (a red color, like cherry or watermelon, works the best)
- 1 cup water

Set up two ***Soil Soakers***, which are the experimental devices you will use for your experiment.

1. Prepare two *Soil Soakers* by cutting off the bottoms of the clear plastic bottles. Put one hole in each screw on cap using a 3/16" diameter nail and hammer or use a 3/16" drill bit (see drawing). *Think safety* — this step might require adult help.



2. Label one bottle as the *Control Soil Soaker* and the other bottle as the *Experimental Soil Soaker*.

3. Put 1 cup of potting soil into the *Control Soil Soaker* and place bottle into tall, narrow drinking glass, lid side down and open side up.

4. Obtain about 1 tablespoon of hydrogel powder (see the Engage activity if you are harvesting hydrogel powder from diapers).

5. Mix 1 cup of potting soil with 1 tablespoon of hydrogel, and place into the *Experimental Soil Soaker*. Place bottle into tall, narrow drinking glass, cap side down and open side up.

Education Standards: *NSES Earth and Space Science Standards:* K-4 properties of earth materials; *Physical Science:* K-4 properties of objects and materials; 5-8 properties and changes of properties in matter; 9-12 structure and properties of matter

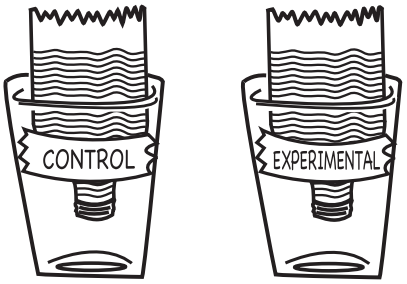
4-H SET Abilities: observe, build/construct, test, problem solve, measure, collect data, compare, communicate with others.

Life Skills: problem solving, wise use of resources, critical thinking.

Success Indicators: perform experiment and record data results on ***www.4-H.org***.

Age Range: K-12 with the help of a caring adult.

6. Mix 1 packet of unsweetened powdered drink mix into 1 cup of water. This solution represents a water soluble fertilizer application. (Water soluble means "capable of being dissolved in water.")



7. Go to ***www.4-H.org*** and enter your results for each of the following steps:

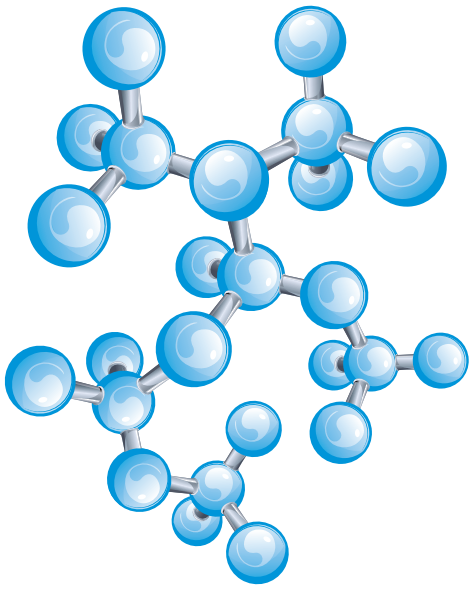
- **Step 1 -** Pour 1/4 cup red solution into EACH of the *Soil Soakers*. Observe. Does any water drain through the soil into the glasses? For the Control - Yes or no? For the Experimental - Yes or no?

- **Step 2 -** Add another 1/4 cup red solution into each *Soil Soaker*. Observe the amount of water that seeps through the soil. Which *Soil Soaker* allowed the least amount of water to seep through? Control or Experimental?

- **Step 3 -** Wait 5 minutes and compare and contrast the solution from each *Soil Soaker*. Answer the following questions.

  – Is there a difference in the amount of water in each glass? Yes or no?
  – Is there a difference in color? Yes or no?
  – Is there a difference in smell? Use a wafting technique (fanning the air over the glass) to check the smell. Yes or no?

- Once you've entered your data, compare your results with others' experiments from around the country? What might explain the differences recorded from samples you find online?



EXPLAIN

Hydrogels in the environment: Can you explain?
Discuss what you think with others at *www.4-H.org*.

Did the addition of the absorbent hydrogel polymer impact the movement of water through the soil? If yes, how?

If the red solution represented a water-soluble fertilizer or chemical pesticide, what conclusions can be drawn about this contamination entering the groundwater?

If more water is retained in the soil, what conclusions can be drawn about the amount of watering needed to help the plants grow? How might this affect water conservation issues?

FAQs about polymers and other useful information.

What are polymers?
Polymers are one of the classes of materials that we encounter throughout the day. Polymers (commonly known as plastics) are either naturally occurring (rubber, RNA and DNA, proteins, starch, and cellulose) or synthetic (manufactured).

What are hydrogels?
Hydrogel polymers are long molecule chains made up of repeating units that grab onto water molecules. This characteristic makes them a great solution for soaking up water.

How are hydrogels helping the environment?
Many environmental applications for hydrogels have been found for agriculture, as well as the the construction and horticulture industries. Hydrogels help reduce water runoff and soil erosion, thus improving the quality of lakes, streams, and rivers. Hydrogels also help with moisture retention and water conservation by helping soil increase water holding capacity, allowing plants to survive during droughts. Erosion control, soil management, and environmental clean-ups are also ways hydrogels can help the environment. Many scientists continue to study the effect of hydrogels on the environment.

ELABORATE

Go beyond...how much hydrogel works for you?

Use what you know about the environmental impact of adding hydrogel to soil. Follow the engineering design process to create a better soil for your garden.

Ask1: How can I conserve water in my garden? How can I prevent contamination of groundwater from fertilizers? Can hydrogel help me accomplish this? Are there different kinds of hydrogels with different properties? Do different soils absorb water at different rates? What is the type of soil in my garden? Can I design a "better soil" that would conserve water and protect the water table from contamination?

Imagine: Designer soil that reduces the number of waterings and, therefore, conserves water. This soil would retain the fertilizer for the plants instead of entering the groundwater and contaminating it.

Create: To craft a designer soil profile, find out about your soil type*: Is it clay, sandy or loamy? Which soil is the most absorbent? Which is the least absorbent? Which one needs more hydrogel? Which needs less hydrogel?**

Test: Using the Soil Soakers experiment, test your own soil with varying amounts of the agricultural version of hydrogel (Polyacrylamide), available in the gardening section of stores. This form of hydrogel is frequently used as a soil conditioner on farmland and construction sites for erosion control, and to protect the water quality of nearby rivers and streams. What is the optimum amount that holds water without "saturating" the soil, making it too soggy for plants? What amount is necessary to retain water and reduce the number of watering times?

Ask2: What is the optimum amount of hydrogel? Can I use other techniques to improve my soil conditions? What other ways can I conserve water in my garden?

***What are soil types?**

There are three basic different types of soils: clay soils, loamy soils and sandy soils. Loamy soils are the best; the other two soils present irrigation challenges. But how do you find out which type of soil you have? Here is the simplest way to check your own soil:

- Take a marble-sized chunk of moist soil and roll it between your thumb and finger; try to shape it into a small ball.
- With a clay soil, you can do it and you end up with a ball the size of a marble.
- With a sandy soil, you cannot do it—the ball will fall apart.
- With a loamy soil, you will be able to do it but the ball will fall apart when you quit applying pressure.

****What different kinds of hydrogels are there?**

The hydrogel polymers found in most disposable diapers are just one kind. Some scientists have found that hydrogels like these don't work well in soil and agricultural use. New, super-absorbent polymers are rapidly becoming one of the most exciting topics in environmental education. Take a trip to your local garden center, and ask the plant specialist if they carry water polymer crystals or water jelly crystals.

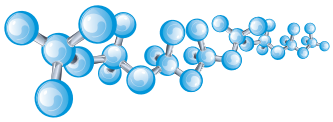
EVALUATE

Go to *www.4-H.org* and submit your results. Compare your answers with others. Submit questions for further investigations.

Share your ideas for other applications of hydrogels. For example, hydrogels have been used to preserve and restore a submarine recovered from the Civil War era, and to make "cool ties" that soldiers can tie around their necks to beat the desert heat. What can you find out about these uses? What other ideas do you have?

Think globally and act locally... get other students to join in with an engineering design challenge. Consider questions like:

- How can hydrogels be used to create lush greenery in sandy soil of arid desert climates?
- How can hydrogels be applied to improve soil irrigation for farmers in developing world countries who are seeking to grow crops in dry climates?
- How can hydrogel be used to improve soil erosion control?
- How are hydrogels being used in medical applications? What are additional ways they can be used?



One Million New Scientists. One Million New Ideas.™

4-H National Youth Science Day is part of comprehensive campaign to support 4-H's goal of attracting 1 million new youth to 4-H science, engineering, and technology programs by the year 2013. 4-H's existing science curriculum, when combined with this new initiative, will arm youth with the technical skills needed to help America maintain its competitive edge in the global marketplace.

A special thank you to the following for their support, expertise, and creativity in designing the 2008 National Science Experiment: Dr. Bob Horton, 4-H science education specialist for The Ohio State University Extension and his team members Carol Warkentien and Jeanne Gogolski; Steve Spangler, science author, teacher and TV personality, and the Steve Spangler Science experiment design team; and members of the 4-H Science, Engineering, and Technology Leadership Task Force who draw knowledge from ten Land-Grant Universities across the country.

4-H, part of the Cooperative Extension System of the United States Department of Agriculture and the 106 Land-Grant Universities across the country, has been educating youth on agriculture and the sciences for over 100 years—and we have lots of ways for youth to explore, engage, and get inspired by science! To learn more about 4-H Science, Engineering, and Technology programs or to explore more 4-H environmental curricula visit ***www.4-H.org.***