Plants: Nature's Filters

Students perform a demonstration of how plants in wetlands and riparian buffers can remove pollution from water.

Level(s): 6-7

Subject(s): Life Science; Earth Science

Virginia SOLs: 6.5 a,f,g; 6.7 a,c,d,f; 6.9 a,c; LS4 a; LS7 a; LS12 e

Objectives: Students will be able to explain the role plants in wetlands and riparian buffers play in protecting water quality

Materials:
For each student group:
1. beaker or jar
2. food coloring (other than green)
3, 1 fresh celery stalk with leaves
4. water
5. knife
6. masking tape (to label beakers)

Estimated Time:
1st session: 15 - 20 minutes
2nd session : 45 minutes

Background Information: *Riparian Buffers,* p. 20; *Wetlands*, p.25.
Plants in wetlands and riparian buffers play many roles in protecting water quality. Some pollutants are converted to less toxic forms by plants while others may remain in the plant and re-enter the environment when the plant dies. The ability of plants to remove pollutants is limited, and cannot replace efforts to reduce the amount of pollution we release into the environment.

Preparation:
Fill each beaker two-thirds full of water and add a few drops of food coloring.

Activity Procedure:
1st Session
1. Discuss with students the roles that plants play in protecting water quality in riparian buffers and wetlands. Tell them they will perform a demonstration of how plants can take in pollutants, removing them from the water.

2. Divide the students into groups of 2-3. Give each group a set of materials. Tell them that the color in the water represents some form of pollution such as heavy metals or nutrients.

3. Have students cut off the bottom half inch of the celery stalks and place them in the water. Each group should use a piece of masking tape to write a label identifying their beaker. Place the beakers someplace where they can be observed during the day.

2nd Session

1. Have students retrieve their beakers and observe the color of the celery.

2. Have students cut the celery stalk and observe the cross-section to see where the dye is present inside the stalk. Have the students draw the cross section.

3. If the teacher wishes, this is also an opportunity to review or discuss transpiration in plants and the role of *phloem* and *xylem*.

4. Discuss how the process they have observed could remove pollutants from water.

Assessment Opportunities:

Ask:

1. How do wetlands help to purify water?
2. Is the water in the beaker still "polluted"? Why or why not?
3. Where does the water go after uptake into the plant?
4. What happens to the pollutants?
5. Why can't we dump all of our waste water into wetlands?

Extensions:

1. Discuss what kinds of plants are found in wetlands.
2. What is the difference between a pond, a wetland, a marsh and a swamp? Discuss how the words we use affect the way we think about things.

from **Discover wetlands: A curriculum guide**, pp.65-73

Riparian Buffers

Adapted from the ***Riparian Buffer Modification & Mitigation Guidance Manual***
DCR web site: http://www.cblad.virginia.gov/ripbuffstat.cfm

Land adjacent to a stream, river, wetland or pond is referred to as a riparian area. If the riparian area has tree and other plant cover, it functions as a buffer, or protective area, and can minimize the impacts of human activity on the water. Vegetated riparian buffers, especially forested buffers, improve water quality, help manage stormwater and floodwater management, stabilize stream banks and shorelines, maintain lower water temperatures, provide wildlife habitat, and absorb of pollutants in the air. The wider the buffer is, the more effective it is. In Virginia, a buffer width of 100-feet has been deemed sufficient to protect water quality through the removal of sediment and nutrients.

Protection from Erosion and Sediment Pollution

In general, the greatest sources of sediment are row crop agricultural fields and construction activities. Livestock that are permitted to enter streams can cause bank destabilization and erosion, adding sediment to the water in a stream. Some lumbering practices can also cause sediment to flow into streams, especially when a site is clear-cut or forest roads are poorly maintained.

Sediment that reaches surface waters is a pollutant that can harm aquatic plants and animals. Riparian buffers help to reduce stream sedimentation in several ways. A buffer may keep farm fields, construction or logging far enough back from the water feature that the disturbance does not directly affect the banks. Buffers can also reduce the speed and amount of stormwater runoff that causes erosion and carries sediment to streams by allowing more water to enter the ground. The vegetation, roots, and leaf litter can trap sediment from surface runoff before it reaches the water. The vegetation, particularly their roots, helps stabilize stream banks, and also provide woody debris within the stream that helps trap sediment. During floods, the buffer moderates the velocity of the storm flow that surges onto the floodplain, reducing erosion, and allowing the sediment to settle out and be deposited on land.

Nutrient and Chemical Control

Plant nutrients such as phosphorus and nitrogen and chemicals such as pesticides and herbicides can reduce water quality and damage habitat. Although there are natural sources of nitrogen and phosphorus, human activity has greatly increased the amount of nutrients reaching ground and surface waters, often leading to algae blooms. In rural areas, agriculture is generally the leading contributor of nutrients, from row crops and livestock operations, but residential lawn fertilization and on-site sewage systems also contribute a significant amount of nutrients and pathogens. In urban areas the runoff from lawns and impervious areas are the principles sources of nutrients. Pesticides and herbicides, like fertilizer, are applied to agricultural fields and residential lawns. These chemicals can harm or kill aquatic organisms.

Riparian buffers can have a significant impact on the removal of nitrogen, especially if they have a mix of plants including trees, shrubs and tall native grasses. Most nitrogen enters the buffer dissolved in the ground water. Trees, shrubs and tall native grasses that have significant deep roots extending into the sub-surface waters can remove nitrogen. Nitrogen can also be used by some soil microbes or adsorbed by soil particles in the buffer. Most phosphorous that is carried by runoff is bound to particles of sediment rather than dissolved in water. For this reason plants in buffers are not able to take in much phosphorous. Still, a riparian buffer can keep phosphorus-producing activity away from the stream, and can prevent particles carrying phosphorous from reaching the stream. Riparian buffers help minimize pesticide problems by keeping pesticide application away from the water feature, preventing direct contamination and reducing the risk of drift. They can reduce the amount of toxins in surface runoff as well. Many pesticides and herbicides are retained in the buffer to decompose over time

Other Contaminants

Other contaminants such as bacteria and viruses, and heavy metals, can also harm aquatic systems. Animal and human waste can supply pathogens and organic matter to surface water. Heavy metals are usually associated with transportation systems and industrial activities, and can enter systems through surface runoff from urban areas. Buffers can trap waste from surface waters, preventing it from reaching water features. Many heavy metals can be bound to soil particles and remain in the buffer. As with nitrogen and phosphorus, the dense vegetative cover and litter layers encourage infiltration of pesticides. The dense root biomass and layers of organic matter support a rich soil capable of transforming dissolved chemicals through enhanced microbial activity.

Hydrologic Benefits

Another important function of the riparian buffer is to slow the rate of stormwater runoff, increasing the potential for infiltration. The recharging of the ground water is important for maintaining wells and supplying the baseflow waters that feed streams. The vegetation is important for maintaining a uniform flow of water through the buffer, allowing longer detention times for pollutant transformation or removal. A uniform flow also helps protect stream and shoreline banks from erosion. During floods, the trunks, stems, twigs, and woody debris within the forested buffers provide a further advantage by slowing the speed of water flow through the floodplain. This reduction in the speed of water flow helps to encourage the settling of sediment and associated contaminants.

Habitat Benefits

A forested buffer improves habitat for animals by providing food, shade, and woody debris or snags for shelter. On land, the habitat benefits from the availability of water, the abundant food supplied by riparian vegetation and the variety of cover provided by trees and shrubs to support numerous organisms. Certain microorganisms and invertebrates at the bottom of the food chain require high quality water to survive. Microorganisms that form the bottom of the food chain break down the leaves, twigs, fruits, nuts, flowers and insects that fall into the stream from a forested buffer. The invertebrates that depend on organic debris and microorganisms are in turn important sources of food for fish. The vegetation in a buffer also supports a healthy insect population, which provides food for fish. Streams and rivers provide habitat for smaller fish which depend on the insects and debris falling from the riparian area, for food.

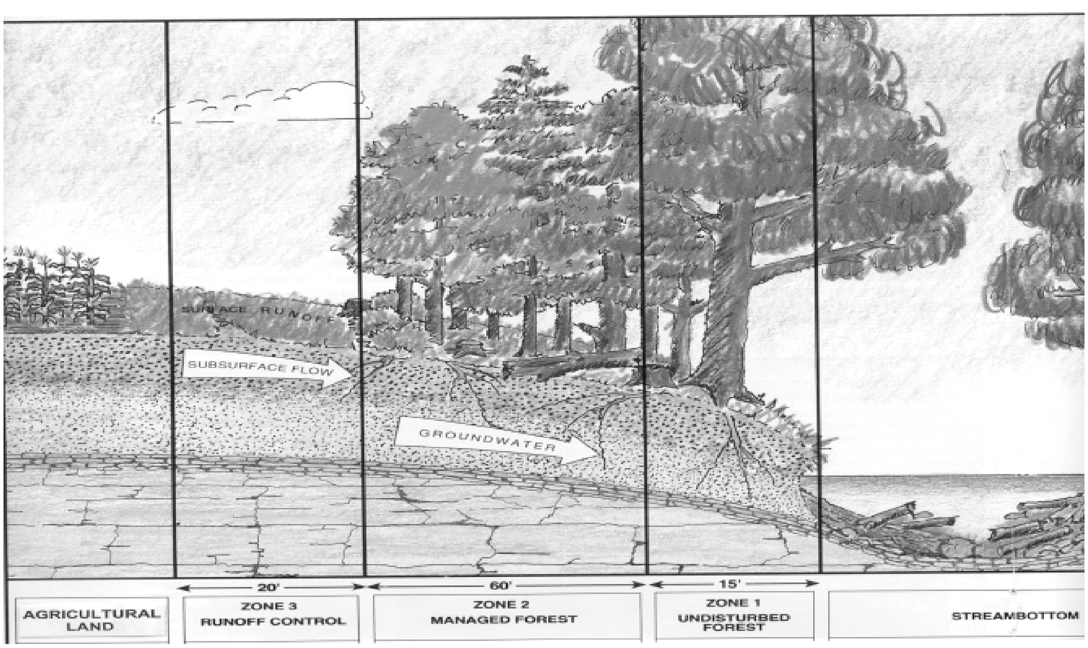
Trees dropping large woody debris into a stream promote a variety of habitat for a variety of aquatic organisms. Large logs help create pools, riffles, or still backwaters that function as places for fish to rest and juveniles to seek shelter. They supply cover from overhead predators and sunning spots for reptiles and amphibians. Logs also provide surface habitats for invertebrates to colonize. Woody debris can capture twigs, leaves, and other organic food items, such as seeds, or provide surface areas for invertebrates to colonize.

The canopy of a forested buffer has a direct affect on the light and temperature of the stream water. The amount of light that reaches the stream is important for the rate of plant and algae growth. Sunlight hitting a stream raises the water temperature. A higher temperature can increase decomposition, decrease the amount of oxygen in the water and increase the amount of nutrients released from suspended sediments. The higher temperature and greater amount of light can encourage the growth of algae and parasitic bacteria while creating an environment that supports a less diverse community. Higher temperatures will prevent some species from thriving and stress others beyond survival.

The complex plant community of a natural buffer provides water, food and shelter for both permanent and migrating species. The availability of food from seeds, fruits, buds and twigs to insects and small mammals makes the buffer an important source of food. The variety and complexity of wooded buffers supplies numerous opportunities for shelter for birds and small animals. Riparian areas provide corridors of habitat within agricultural settings and may provide the only natural areas in urban landscapes.

Riparian buffers benefit everyone by protecting water quality, maintaining stream health, reducing flood damage and erosion, and by providing good habitat for a wide range of animals and plants. They also improve local air quality by removing pollutants from the air. In addition, these stream corridors, when surrounded by a healthy plant cover, improve the landscape and serve as ideal places for recreational activities such as walking, bicycling, picnicking, fishing, swimming and bird watching.

3-ZONE STREAMSIDE BUFFER



Wetlands: Our Natural Purification System

Students perform an experiment on how the sediments in wetlands help to filter pollutants out of surface water before entering the groundwater.

Level(s): 6-8

Subject(s): Life Science, Earth Science, Physical Science

Virginia SOLs: 6.5 b,e,g; 6.7 a,d,f; 6.9 a,c; LS7 a,c; LS10 b; LS12 e; PS2 b,c,f

Objectives:
Students will be able to explain the role sediments in wetlands play in removing pollution from water.

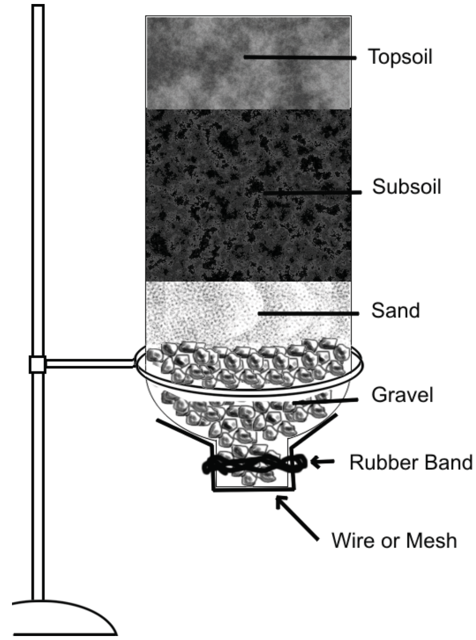
Materials:
1. 5 used one-liter plastic bottles with the bottoms cut off
2. 5 three-inch squares of wire screen or plastic mesh
3. 5 ring stands
4. rich topsoil (with organic material)
5. subsoil
6. sand
7. small gravel or pebbles
8. 300 ml of water mixed with 100 ml of **vinegar**
9. 400 ml of water mixed with 3 tablespoons of **baking soda**
10. 300 ml of water mixed with 100 ml of **rubbing alcohol**
11. 400 ml of water mixed with 1 teaspoon of **red food coloring**
12. 400 ml of water mixed with 3 tablespoons of pulverized **charcoal briquettes**
13. 3 tablespoons each of **talcum powder**, **leaf mulch** (oregano can be used), fine ground **black pepper** (see *Note* for Activity Procedure Step #4 below).
14. litmus paper (for pH test)
15. 5 500 ml beakers or jars
16. 5 pieces of cloth (for filtering water discarded down the drain)
17. rubber bands

Estimated Time: 45-50 minutes

Background Information: *Wetlands***,** p.25.
Sediments in wetlands filter out pollutants as they seep down to the groundwater. Some of these pollutants may be converted to less harmful forms through the action of bacteria, and others may remain in sediments until disturbed by some action such as dredging, draining or development of a wetland.

Preparation:
Have the materials ready for students to assemble at five stations. Each station will have one of the pollutant solutions (# 8-13 above).

Activity Procedure:



1. Divide the students into five groups, assign each group to a station and have them set up the filter system as shown in the diagram on the right.

2. Tell the students that there is a water sample at each station that has been contaminated by a pollutant. Have the students observe, smell and test the pH of each "pollutant" (no tasting) and record their observations before they begin. Ask them to record their prediction of what they think will be the result when they pour their polluted water through the filter system.

3. Next, each team slowly pours its contaminated water through the filter, catching the flow out the bottom. Have the students repeat their examination of the liquid, recording their observations. Students should discard the outflow by filtering it through a piece of cloth when they pour it down the drain.

4. First have students record their prediction of how many 400 ml containers of clear water will have to run through the system before they can no longer detect the pollutant. Then have the students flush the system of pollutant by pouring 400 ml amounts of clear water through it. Test and record descriptions of the outflow. Repeat the process with clear water until the pollutant cannot be detected in the outflow. ***Note*:** The group using the charcoal mixture will probably find that all of the charcoal is eliminated the first time through. Have them repeat the process with some other particles, such as talcum powder, soil, ground leaf mulch, and/or ground black pepper and report any differences)

5. Discuss how the results of each experiment might apply to different types of pollution.

Assessment Opportunities:
Have students explain the role sediments play in removing pollution from water.

Extensions:
1. Try the experiment with a stronger solution of each contaminant.
2. Have students locate wetlands nearest the school on a topographic map. Locate the source of water for the wetland and determine what types of pollution might be fond there. Visit the wetland and test the water and sediments there for pollution,
3. Follow up with *Plants: Nature's Filters*

from **Discover wetlands: A curriculum guide** pp.65-73

Wetlands

Wetlands are a prime natural resource and include such areas as swamps, bogs and coastal marshes. These are areas that have standing water at least part of the year. Wetlands are usually identified by the presence of certain types of soils and vegetation that are associated with wet or damp conditions. Many wetlands are transitional areas located between dry lands and deeper aquatic systems like rivers and lakes.

All of these damp areas have tremendous importance in terms of productivity. Wetlands provide feeding, spawning, and nursery grounds for finfish and shellfish. They provide habitat for about half of all endangered species of plants and animals.

Wetlands lessen global warming by locking up huge amounts of carbon in peat rather than allowing CO_2 to be released in the atmosphere. They also clean the water by absorbing and filtering pollutants. Some pollutants are converted to less toxic forms by plants, while others may remain in the plant and re-enter the environment when the plant dies.

Wetlands also play a role in preventing the erosion of shore lines, and they provide a buffer against storm tides. They absorb large quantities of water, preventing or lessening the effects of flooding, and they may serve as “holding” tanks to recharge wells and aquifers.

Some wetlands develop in low-lying areas where water drains and collects. Others border salt or fresh bodies of water, such as oceans, rivers, or ponds, while still others are isolated in forests and urban areas. As transitional zones between upland and aquatic systems, wetlands often support both terrestrial and aquatic species, contributing to the local and regional diversity of plants and animals.

Two hundred years ago, the United States had 220 million acres of wetlands. Now we have less than 100 million acres. As of 1996, the loss was around 300,000 acres each year. Half of the Florida Everglades is gone; half of Connecticut’s coastal wetlands and 2/3 of the prairie potholes are gone. California has only 9% of its wetlands remaining, Iowa 11%, and Indiana and Missouri 13%.

Functions Of Wetlands

1. Wetlands provide habitats for fish, wildlife and plants. They are critical to the survival of a wide variety of organisms. They also provide food, water, or cover for many species.

2. Wetlands provide critical habitats for endangered species. A number of rare and threatened species depend on wetlands for their survival.

3. Wetlands provide flood control and protection. Some wetlands store flood waters or water that collects in isolated depressions. Wetland plants can help to slow the speed of flood waters to protect nearby properties.

4. Wetlands improve water quality serving as excellent water filters to remove nutrients, wastes, and sediment from runoff water before they reach an open body of water. These nutrients, wastes and sediment may cause algae blooms or decrease the volume of a lake, pond, or river.

5. Wetlands provide shoreline erosion control. Those located between rivers and high ground to help to buffer shorelines against erosion. Wetland plants strengthen the sediment by binding soil with their roots. They also dampen wave action.

6. Wetlands reduce storm damage by serving as buffers between the winds and waves of storms and the coastal areas. Property located behind wetlands along shorelines and large lakes often fares much better during storms than unprotected areas.

7. Wetlands facilitate groundwater recharge. As the water moves slowly through the wetlands, some will seep down into aquifers below.

8. Wetlands provide a variety of natural products. These range from fish, shellfish, and wildlife to timber, berries, and wild rice.

9. Wetlands provide areas for recreation, rest, and enjoyment. Hunting, boating, and fishing are allowed in many wetland areas. Artists and photographers enjoy capturing the beauty of wetlands in their crafts. Tourists and visitors often find peace and appreciation for these natural areas.

10. Wetlands facilitate education and research. Although much is known about the functions of wetlands, researchers are still studying these environments and the species that thrive there in an attempt to discover more fully the benefits that they bring to humans.

Terms

bog: freshwater marsh with build-up of peat and high acidity that typically supports mosses adapted to acidic soil conditions (particularly, sphagnum); many are located in colder regions

bottomlands: lowlands along streams and rivers that are typically flooded **cypress**

domes: small, depressional swamps, typically with tall cypress trees at center, characterized by subsurface hardpan overlain by organic matter

estuary: a marine ecosystem where freshwater enters the ocean. The term usually describes regions near the mouths of rivers, and includes bays, lagoons, sounds, and marshes.

forested wetland: wetland dominated by trees. "Trees" (for the purpose of this definition) are defined as woody vegetation with diameter greater than 3 inches at breast height (approx. 4 feet from ground level).

freshwater marsh: a wetland frequently or continually inundated by freshwater, characterized by emergent herbaceous vegetation

mangrove swamps: tropical, wet, coastal areas dominated by mangroves (trees). Mangroves have extensive root systems which form a dense thicket, providing cover for aquatic life.

prairie potholes: shallow, marsh-like ponds which serve as primary breeding grounds for ducks and migratory birds found in North Dakota, South Dakota, Minnesota, and Canada

runoff: water (originating as precipitation) that flows across the surface of the land rather than soaking in; eventually enters a waterbody; may pick up and carry a variety of pollutants

salt marsh: estuary habitat submerged at high tide, but protected from direct wave action, and overgrown by salt-tolerant herbaceous vegetation; aquatic grasslands (coastal "prairies") affected by changing tides, temperatures, and salinity

swamp: wetland dominated by shrubs and trees

Adapted from the U.S. Environmental Protection Agency **Water Sourcebook**
http://www.epa.gov/safewater/kids/wsb/index.html#9-12