Source Water Protection Downstream

Lesson: 16

National Science Education Standards for Grades 9-12

Content Standard A: Scientific Inquiry: Abilities Necessary to Do Scientific Inquiry

Content Standard C: Life Science: The Interdependence of Organisms

- *Organisms both cooperate and compete in ecosystems. The interrelationships and interdependencies of these organisms may generate ecosystems that are stable for hundreds or thousands of years.*
- *Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite. This fundamental tension has profound effects on the interactions between organisms.*
- *Human beings live within the world's ecosystems. Increasingly, humans modify ecosystems as a result of population growth, technology and consumption. Human destruction of habitats through direct harvesting, pollution, atmospheric changes and other factors is threatening current global stability, and if not addressed, ecosystems will be irreversibly affected.*

Content Standard F: Science in Personal and Social Perspectives: Environmental Quality

- *Natural ecosystems provide an array of basic processes that affect humans. Those processes include maintenance of the quality of the atmosphere, generation of soils, control of the hydrologic cycle, disposal of wastes and recycling of nutrients. Humans are changing many of the basic processes, and the changes may be detrimental to humans.*

National Science Education Standards for Grades 9-12

Content Standard F: Science in Personal and Social Perspectives: Science and Technology in Local, National and Global Challenges

- *Humans have a major effect on other species. For example, the influence of humans on other organisms occurs through land use—which decreases space available to other species—and pollution—which changes the chemical composition of air, soil and water*

Student Learning Objectives

16.1 Describe the connections between farming activities, especially in areas of intense agricultural land use, and resulting water quality downstream and local impact on community and farm drinking water.

16.2 Define the term "wetland" and explain the benefits of wetlands for protecting sources of drinking water.

Teacher Info Table Time

Instruction time for this lesson: 50 minutes

Resources, Tools, Equipment and Supplies

16.1. Describe the connections between farming activities, especially in areas of intense agricultural land use, and resulting water quality downstream.

Resources

- Slide WI16.1.TM: *The Mississippi River Watershed*
- Worksheet SW.16.1.a.AS: *Anticipation Guide for Articles about Nutrients in the Gulf of Mexico*
- Worksheet SW.16.1.b.AS: *From Minnesota to the Gulf of Mexico*
- Worksheet SW.16.1.c.AS: *Gulf Coast Program Awards Iowa*
- *The Gulf of Mexico Hypoxic Zone*, USGS: http://toxics.usgs.gov/hypoxia/hypoxic_zone.html
- *Mississippi River Gulf of Mexico Watershed Nutrient Task Force,* http://water.epa.gov/type/watersheds/named/msbasin/index.cfm
- *Nutrient Pollution and Hypoxia – Everything Is Upstream of the Coast*, NOAA: http://stateofthecoast.noaa.gov/hypoxia/welcome.html

Resources, Tools, Equipment and Supplies

16.1. Resources *(continued)*

- Onsite wastewater treatment systems and municipal wastewater treatment systems: http://water.epa.gove/scitec/swguidance/standards/criteria/nutrients/whywastewater.cfm
- Surf your watershed site: http://cfpub.epa.gov/surf/locate/index.cfm
- National wetlands inventory: http://fws.gov/wetlands. This U.S. fish and wildlife service site has the national wetlands inventory, wetlands mapper and a link to view wetlands or google earth.
- Nutrient Pollution - What Is It And What You Can Do, http://epa.gov.nutrientpollution
- Hypoxia in the News: http://water.epa.gov/type/watersheds/named/msbasin/gulfnews.cfm

16.1. Equipment and Supplies

Computer
LCD projector

Resources, Tools, Equipment and Supplies

16.2. Define the term “wetland” and explain the benefits of wetlands for protecting sources of drinking water.

Resources

- Slide SW.16.2.TM: Wetlands
- America’s Wetlands: Our Vital Link Between Land and Water, U.S. EPA: http://www.epa.gov/owow/wetlands/vital/wetlands.pdf
- National Wetlands Inventory, U.S. FWS: http://www.fws.gov/wetlands/
- Wetland Ecosystems, Ecosystem Conservation, U.S. FWS: http://www.fws.gov/midwest/EcosystemConservation/wetland.html
- Wetlands: Where Water Meets Lands, U.S. EPA: http://water.epa.gov/type/wetlands/index.cfm
- WOW! The Wonders of Wetlands – An Educator’s Guide: http://www.wetland.org/education_wow.htm
- USFWS Wetland Loss Numbers: http://fws.gov/wetlands/docs/status trends wetlands conterminous us2004to2009.pdf

Equipment and Supplies

Computer
LCD projector

Key Terms

Constructed wetland

Dead zone

Hypoxia

Mississippi River watershed or basin

Nitrogen

Nutrients

Phosphorus

Tile drains

Wetlands

SUMMARY OF CONTENT AND TEACHING STRATEGIES: (BACKGROUND FOR TEACHERS)

The Mississippi River[1]

The Mississippi River is important in several contexts.

(1) It serves as drinking-water supply for 70 cities and towns. Thus, the contaminants in the waters of the Mississippi River have the potential for detrimental health effects on these consumers of river water. Some of these contaminants, of course, are removed in water-treatment plants, but some persist regardless of the treatment process. The analysis of river waters provides an indication of the potential for drinking-water contamination and impact on cost of drinking water treatment, and potential impact on public health.

(2) The birds, fish and other organisms that live in or adjacent to the Mississippi River are affected by contaminants. Thus, there is a basis for interest from an ecological perspective as well as from the perspective of the health of humans who consume the birds and fish.

(3) The Mississippi River is a significant source of water, sediment, and nutrients to the Gulf of Mexico. The chemical characteristics of these flows are important to the health and productivity of coastal and marine ecosystems.

(4) The Mississippi River drains 41 percent of the conterminous United States, in which area nearly 30 percent of the nation's population reside. The contaminants moving through the river system are an excellent measure of what is being introduced into the nation's waterways by human activities. In a sense, they are "report cards" on the nation's efforts at water-pollution control.

Ecosystems

A. Ecosystem – A community of living organisms and their interrelated physical and chemical environment. Aquatic ecosystems are those involving water.

B. Marine ecosystems

1. Part of the largest aquatic system on the planet covering 70 percent of the Earth's surface
2. Habitats range from near-shore regions to the barren ocean floor
3. Examples: Oceans, estuaries, coral reefs, coastal areas (lagoons)

C. Freshwater ecosystems

1. Contain drinkable water or water of almost no salt content

1 Adapted from USGS http://pubs.usgs.gov/circ/circ1133/introduction.html

2. Provide majority of drinking water sources
3. Home to many organisms; estimated that 40 percent of all known fish species on Earth come from freshwater ecosystems
4. Examples: Lakes and ponds, rivers and streams, reservoirs, wetlands, groundwater

D. Organism Adaptability

1. In areas like estuaries, tidal and freshwater influences from rivers and streams cause fluctuating salinity (salt) levels
2. Organisms in these areas must be able to adapt to a wide range of salinity levels; called euryhaline species (examples: Mussels, clams, barnacles)
3. Other organisms are unable to tolerate these changes (called stenohaline species) and can only survive in areas where changes in salinity are minimal

E. What impact do people have on aquatic ecosystems?

1. Human activities are causing species to disappear at an alarming rate
2. Estimated that from 1975 – 2015, species extinction will occur at a rate of 1-11 percent per decade
3. Losses of species impact the entire ecosystem, depriving valuable resources for food, recreation, medicines and industrial materials
4. Nutrients (nitrogen and phosphorus), sediment, and mercury pollution are some of the top causes of water quality impairment
5. Examples of negative human impacts on water quality include:
   a) Runoff from agricultural and urban areas, household lawns and urban areas
   b) High levels of nitrogen and phosphorus in water can produce harmful algal blooms. These blooms can produce “dead zones” in water bodies where dissolved oxygen levels are so low that most aquatic life cannot survive. This is one of the top causes of water quality impairments and is becoming one of the most expensive environmental issues of our time. Infants who drink water contaminated with nitrates can suffer from methemoglobinemia, or blue baby syndrome, a condition that can cause brain damage or death. Human health can also be impacted by disinfection byproducts formed when disinfectants (such as chlorine) used to treat drinking water react with organic carbon (from the algae in source waters). Some disinfection byproducts have been linked to cancer; reproductive health risks; and nervous system problems.

Consuming seafood that contains toxins from certain types of algae know as cyanobacteria can most commonly lead to stomach illness and short-term memory problems.

c) Invasion of exotic species
d) Hydrological modifications, including tile drains, creation of dams and water diversions
e) Over fishing in marine ecosystems
f) Urban development and resource-based industries (forestry & mining)
g) Air and water pollution, erosion, climate change
h) Draining and filling of wetlands

Wetland Ecosystems[2]

Wetlands share three basic characteristics: (1) hydrology (water); (2) hydric soils (soils that form due to the saturating presence of water; and (3) hydrophytic vegetation (plants adapted to living in saturated soils).

Wetland ecosystems are among the most productive areas on earth. In the United States, wetlands are important because they provide habitat for about one-third of our Federally listed threatened or endangered plant and animal species, as well as essential nesting, migratory, and wintering areas for more than 50 percent of our nation's migratory bird species. More than one third of our nation's biological organisms are found in wetlands, yet wetlands occupy a mere three percent of our nation's land surface. Wetlands provide society a variety of goods and services, including habitat for fish and wildlife of recreational importance; flood water storage, water quality, and sediment control; and vegetation that contributes to the maintenance of the bio-geochemical cycles of nitrogen, carbon and methane, which are important in the preservation of the earth's atmosphere.

U.S. FWS[3]

2 From Wetland Ecosystems, Ecosystem Conservation, U.S. FWS: http://www.fws.gov/midwest/EcosystemConservation/wetland.html

3 From Wetland Ecosystems, Ecosystem Conservation, U.S. FWS: http://www.fws.gov/midwest/EcosystemConservation/wetland.html

Of the estimated 64 million acres of wetlands present in the Midwest's Great Lakes region at the time of colonial America, only 23 million acres remain (Dahl 1990)[4]. Draining, dredging, filling, leveling, and flooding have reduced wetlands by 50 percent or more in six states, and five states have lost 80 percent or more of their wetlands. Of the wetlands that do remain in this area, only a small percentage remain as they existed 200 years ago, and few support their original complement of plants and animals.

Types of Wetlands[5]

Wetlands are areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year. Water saturation largely determines how the soil develops and the types of plant and animal communities living in and on the soil. Wetlands may support both aquatic and terrestrial species. The prolonged presence of water creates conditions that favor the growth of specially adapted plants and promote the development of characteristic wetlands soils.

EPA, America's Wetlands: Our Vital Link Between Land and Water

These are many types of wetlands in the United States:

- Marshes
  - Tidal
  - Nontidal
    - Wet meadows
    - Prairie potholes
    - Vernal pools
    - Playa lakes
- Swamps
  - Forested swamps
  - Bottomland hardwoods
  - Shrub swamps
  - Mangrove swamps
- Bogs
  - Northern bogs
  - Pocosins
- Fens

4 Dahl, T. E. (1990). Wetland Losses in the U.S. 1780's-1980's. U.S. FWS. Retrieved from USGS Northern Prairie Wildlife Research Center: http://www.npwrc.usgs.gov/resource/wetlands/wetloss/.

5 Adapted from http://water.epa.gov/type/wetlands/types_index.cfm

Wetland Values[6]

Wetlands provide local benefits and improve water quality downstream. Wetlands were long thought to be a nuisance because they were not suitable for development or most kinds of agriculture. We now realize wetlands are not just valuable, they are invaluable. Wetlands reduce nutrients locally and result in fewer problems with local drinking water and swimming/fishing holes. When wetlands connect to rivers, they have direct impacts on the quantity and quality of water in those rivers. They improve water quality downstream and do not contribute to hypoxia or dead zones, a condition to be addressed later in this lesson. The following is a list of ways in which wetlands benefit people and the environment.

Flood damage control: Wetlands adjacent to rivers (riparian wetlands) can easily survive inundation by floodwaters and often actually benefit from regular flooding. Water that is allowed to flow over wetlands is slowed and partially absorbed, thereby reducing flood damage downstream. Wetlands are said to act as sponges because wetland soils can readily absorb water, and depressions associated with wetlands can fill up. This has the effect of trapping and slowly releasing water that would otherwise rush into the channel and contribute to flooding downstream.

Bank Stabilization: Riparian vegetation is amazingly good at holding banks together. The deep binding root masses of such plants gives the stream-banks the ability to withstand erosion, which prevents sediment from entering the stream. Native riparian vegetation is generally much more effective at holding banks together than exotic species. Shrubs and sedges typically provide the most stream stability.

Water supply and groundwater recharge: Wetlands act as sources of water even in very arid regions. A properly functioning wetland can provide water for humans, livestock, and wildlife. Water flows out of wetlands and into the water table below neighboring habitats as these habitats dry out. This process is known as groundwater recharge, and helps habitats around wetlands survive drought. This slow release of stored water also helps rivers maintain flows in the summer.

Water purification: Not only do wetlands act as a sponge, they also act as a filter. Certain types of wetlands are efficient at removing toxins, and excess nutrients from surface and groundwater. Wetlands can also filter the sediment out of floodwaters. As flood waters flow over land, the water velocity is lowered and sediment settles out onto the floodplain. Wetlands also control sediment by decreasing the volume and velocity of flows during high water events which decreases channel erosion.

6 From *http://www.umt.edu/watershedclinic/links/clarkfork/wetlands/wetlandvalues.htm*

Threats to Wetlands[7][8]

Wetlands have been steadily and rapidly disappearing across the country since the beginning of European settlement. Wetlands occupied 11 percent of the surface area of the lower 48 states just 200 years ago. Today, they cover about five percent of the surface area. Laws created in the last half-century have attempted to stop the loss of wetlands in the US, but the loss continues. This loss is mainly associated with certain land uses. Wetland loss has had, and continues to have, negative impacts on drinking water sources. Land uses with the greatest impact on many wetlands are:

Development that Occurs in Floodplains: Floodplain development often directly impacts wetlands by removing vegetation (increasing bank erosion), and filling or draining wetlands for building sites. Floodplain development sometimes indirectly impacts riparian wetlands through the installation of artificial stream stabilizing devices like rip-rap and bulk-heads that attempt to stop the natural meandering process which creates new wetlands and replenishes existing ones. The building of berms, dykes and levees that close off the floodplains from their rivers has resulted in the loss of millions of acres of wetlands.

Road Building: The “S” shape of rivers and streams are called meanders. Meanders help to dissipate energy or slow streams down. Most river valleys have roads and/or railroads. These structures squeeze rivers and streams by narrowing the floodplain. This destabilizes the river which has less room to meander and therefore has an excess of energy, which can lead to more streambank destruction and flooding. The roads and railroads also affect drainage from uplands onto the floodplains, and many are built on top of areas that once were wetlands. Such roads often create long, low-quality wetlands upslope of the road by interrupting surface and groundwater flows. These wetlands can attract wildlife dangerously close to roads. Wetland loss caused by roads can be mitigated through the restoration of other impacted wetlands although the replacement wetlands are not always of the same type and quality as those lost.

Grazing: Overgrazing harms wetlands through soil compaction, removal of vegetation, and stream bank destabilization. Wetlands offer some of the best forage for livestock as well as a water source and cover, so livestock tends to spend a disproportionately large time in wetlands. There are many grazing strategies that discourage cattle from using wetlands such as providing alternative water sources and fencing cattle out of wetlands and streams.

Agriculture: Wetlands often have fairly flat areas of rich organic soil that is highly productive agricultural land if drained. For this reason many wetlands have been drained and converted to agricultural lands. The drainage not only results in a loss of wetlands, but it increases the delivery of nutrient loads downstream and impacts water quality. Wetlands serve as nutrient sinks in the landscape.

7 Adapted from *http://www.umt.edu/watershedclinic/links/clarkfork/wetlands/threatstowetlands.htm*

8 Adapted from Schaefer, M., & Burkett, V. (1997). Wetland Losses in the United States: Scope, Causes, Impacts, and Future Prospects. U.S. Global Change Research Program Seminar, 7 July 1997. Retrieved from: http://www.usgcrp.gov/usgcrp/seminars/9777DD.html

Mining: Mining can have a major impact on wetlands when mine wastes are deposited in floodplains and wetlands. The filling in of these wetlands impacts downstream waters and may result in (1) increases in flooding; (2) pollutant inputs downstream; and (3) contamination of drinking water sources.

The EPA also lists the following as major human causes of wetland loss: logging, runoff, air and water pollution, introducing nonnative species.

The following list illustrates human actions that can negatively affect wetlands:

Dumping: Dumping fill material buries hydric soils and effectively lowers the water table so hydrophytic (water loving) plants cannot compete with upland plants.

Dredging: The removal of material from a wetland or river bed. Dredging of streams lowers the surrounding water table and water available for drinking water, and dries up adjacent wetlands.

Draining: Water is drained from wetlands by cutting ditches into the ground, which collect and transport water out of the wetland. This lowers the water table and dries out the wetland.

Diverting flow: Water is diverted around wetlands, lowering the water table.

Devegetation: Vegetation plays an important role in wetland ecology by removing water through evapotranspiration, altering water and soil chemistry, providing habitat for wildlife, and reducing erosion. Removal of vegetation can drastically and sometimes irreversibly alter wetland function.

Damming flow: Many ponds and reservoirs are constructed on wetlands. A flooded wetland cannot provide the same habitats and functions.

Development of springs: Pumping large quantities of water from springs lowers nearby groundwater and can result in the loss of wetland vegetation and available drinking water. Compaction of springs by cattle can cause springs to cease to flow.

INTEREST APPROACH:

Lesson 16 guides student exploration of the impacts of human activity on wetlands and the positive impacts of healthy wetlands on water resources, our communities, and in some cases communities far away.

A suggestion for opening this lesson: Have you ever been in a situation where someone asked you to turn down your music? Maybe you didn't realize that this person could hear your radio, or was even there. Have you ever had someone light a cigarette or cigar nearby and have the smoke waft right to you? How often do humans take actions that impact others without realizing it? In today's lesson we'll look at some impacts that farm practices in one part of the country can have in areas hundreds, and even thousands, of miles away.

OBJECTIVE BY OBJECTIVE:

Activity Outline and Teacher Support Information:

The focus throughout this series of lessons on source water protection has been on local, rural communities. Students have been encouraged, as they learn about drinking water sources to think of them in the context of issues that are relevant to their lives and their communities. In this lesson, students will change that focus to see a local farm or their farming community less like an island and more like part of a regional or national community. Decisions made in farming communities throughout the U.S. have cumulative effects on large bodies of water, including the Great Lakes, Chesapeake Bay, the Mississippi River and the Gulf of Mexico. Huge geographic areas drain into these large waterbodies and along with the water comes large amounts of pollutants such as sediment, nutrients, and pesticides, which can also affect the quality of local drinking water sources.

For example, the vast Mississippi River watershed or basin drains 1,245,000 square miles of land. The Mississippi River, which starts its journey in northern Minnesota, travels over 2300 miles to discharge into the Gulf of Mexico. Along the way, it receives water from 31 states and two Canadian provinces. Conservation practices within the Basin have impacts within each community but also outside the community, as illustrated by the cumulative effect of poor conservation practices on the Gulf of Mexico. Applying good conservation practices locally, such as protecting wetlands, establishing riparian buffers and reducing fertilizer runoff from fields through careful application, can have a positive effect downstream. Apply nutrients at the right rate by using soil tests and realistic yield goals, at the right time (as close to crop uptake as possible and by avoiding spreading just before a rain or snow), with the right method (incorporating as soon after application as possible), and the right form.

16.1. Describe the connections between farming activities, especially in areas of intense agricultural land use, and resulting water quality downstream.

Show slide SW.16.1, *The Mississippi River Basin and the Hypoxic Zone*. Point out the large tributaries that discharge into the Mississippi and the path of the River from Minnesota to the Gulf.

This Mississippi Watershed drains a particularly large area of farm lands, where the primary nutrients of concern are nitrogen and phosphorus. These nutrients are essential to terrestrial and aquatic ecosystems, but when they are applied in excess, they can disrupt the natural functioning of ecosystems, as well as disrupt human systems, such as recreational and economic opportunities. Excessive nutrients can cause local water quality problems. Many estuaries across the country are negatively impacted by them. Nutrients can cause impairment in both fresh and salt water. Not all nutrients that enter streams will travel far; some are removed through natural processes.

Activity

In this activity students read two newspaper articles that focus on a watershed-scale environmental problem: nutrient enrichment in the Mississippi River watershed that leads to the "dead zone" in the Gulf of Mexico. They first complete an *Anticipation Guide* to stimulate thinking about environmental problems from a watershed perspective and preview ideas described in the two news articles they will read.

Show slide WI16.1.TM: *The Mississippi River Watershed*. Explain that this diagram illustrates the large geographic network of the Mississippi River Watershed. The small rivers and streams within this area flow into ever larger rivers and streams to eventually flow into the Mississippi and finally the Gulf of Mexico. Excessive nutrients from the Mississippi watershed have created a dead or hypoxic zone in the Gulf, which is shown in gold/orange on the map.

Pass out copies of worksheet SW.16.1.a.AS: *Anticipation Guide for Articles about Nutrients in the Gulf of Mexico*. Students will first complete the *Anticipation Guide* individually. Encourage students to jot down brief notes in their journals explaining their reason(s) for making each choice.

Next, pass out copies of the newspaper articles, *From Minnesota to the Gulf of Mexico* and *Gulf Coast program awards Iowa*, and their accompanying questions on worksheets SW.16.2.B.AS and SW.16.2.C.AS. Depending on how much time you have available and how quickly your students read, you may wish to have every student read both articles, or divide the class in half and assign each half one of the articles. Students may then "jigsaw," or pair up so that each pair includes someone who read each article, and compare notes about their articles.

Finally, ask students to revisit their *Anticipation Guide*, and see whether they would change any of their answers after reading the articles. Again, ask students to discuss with a neighbor how their ideas may have changed as a result of reading the articles.

16.2. Define the term "wetland" and explain the benefits of wetlands for protecting sources of drinking water.

Ask students to define the term "wetland" and write their definitions in their journals. Review the definition of wetlands in slide SW.16.2., *Wetlands.* Lead students in a brainstorming activity about wetlands. Ask the students to picture a local wetland in their minds. What are the living components of the wetland? What are the non-living components? What are some connections between the living and non-living components? Where is the wetland they're imagining? How might wetlands protect water resources in our community? What types of activities damage wetlands? (See list on page 8.) What conservation practices discussed in previous lessons might help to protect wetlands?

REVIEW / SUMMARY:

Draw a picture in your journal to show the events leading up to hypoxia in the area known as the “dead zone” in the Gulf of Mexico. Include and label the following: farm fields, urban wastewater, nitrogen, Mississippi River, algae, oxygen. Now also draw wetlands in your picture and write a sentence to describe their roles in preventing hypoxia.

APPLICATION:

Take a field trip to a local farm or have a farmer or extension agent visit class to show how soil testing is done to determine whether fertilizers need to be applied to fields or home lawns.

Take a field trip to a local farm that is participating in a Conservation Reserve Program to help reduce the severity of hypoxia.

Take a field trip to a wetland on a farm, perhaps one reestablished under the Wetland Reserve Program.

Online, look up epa.gov/nutrient/pollution/npdat. Launch the Data Access Tool under Quick Links. Enter state or zip code on the search bar. In the Mississippi River Basin states in the center of the U.S., you can view the watersheds that account for the highest nitrogen and phosphorus yields delivered to the Gulf of Mexico. You will also be able to see which of these watersheds have the highest density of local public water supplies from groundwater and/or surface water.

EVALUATION AND ANSWERS:

SW.16.ASSESS

1. Define the term hypoxia and give two examples of negative consequences that it has in the Gulf of Mexico and two examples of negative consequences in upstream waters.

2. Describe the events that cause hypoxia in the Gulf of Mexico.

3. Name two actions farmers and homeowners can take to help prevent hypoxia.

Answers to SW.16.ASSESS

1. Define the term hypoxia and give two examples of negative consequences that it has in the Gulf of Mexico.

   Hypoxia is a condition in which excess nutrients lead to a dead zone in the water, devoid of any aquatic life. Students may also mention that it is a condition in which small organisms use up all or most of the available oxygen in the water. Locally, drinking water has elevated nitrate levels, increasing the cost to consumers for treatment (or threat to public health where high nitrate levels are not treated), and use of local water bodies for recreation is limited due to algae blooms.

   Negative consequences include: fish and other organisms die or move to other areas; it is more difficult and takes more time for fishermen to catch seafood; seafood become more expensive; consumers pay more for treated drinking water or their health may be at risk from untreated drinking water in private wells.

2. Describe the events that cause hypoxia in the Gulf of Mexico.

   Hypoxia is a condition in which excess nutrients, especially nitrogen and phosphorus, lead to the development of a “dead zone” in the water, which can be devoid of aquatic life. Students may also mention that it is a condition in which algae that blooms as a result of excess nutrients causes dissolved oxygen availability to be reduced when the algae dies and is decomposed.

   Events:

   a. Nitrogen and phosphorous enter streams from farm fields, urban wastewater, and other sources.
   b. Streams drain into the Mississippi River.
   c. The Mississippi River carries the nutrients to the Gulf of Mexico.
   d. The nutrients cause unnaturally high amounts of algae, which need the nutrients to survive and carry out normal functions.
   e. The algae die and sink to the bottom of the Gulf.
   f. Bacteria decomposing the algae use up most or all of the oxygen in the water.
   g. The lack of oxygen makes it difficult or impossible for other organisms to grow and can negatively impact habitats and food chains.

Answers to SW.16.ASSESS *(continued)*

3. Name two actions farmers and homeowners can take to help prevent hypoxia.

   Actions include: building wetlands, especially at the end of tile drains; only applying as much fertilizer as is needed and when it is most beneficial; fencing livestock out of streams and providing alternate water source; avoiding or using only limited chemical fertilizers on lawns; using low or no-phosphorous detergents; collecting and composting leaves, branches, and lawn trimmings rather than putting them in the garbage; collecting runoff using a rain barrel; planting a rain garden to capture runoff from roofs and pavement.

ACTIVITY WORKSHEET(S) – AS NEEDED:

SW.16.2.A.AS – Activity Worksheet

Anticipation Guide for Articles about Nutrients in the Gulf of Mexico

Directions: Please read each statement to yourself and mark whether you think it is True or False. Jot down some notes under each question to remind yourself later about why you made that choice.

_____1. The Minnesota River is too far from the Gulf of Mexico to have much effect on it.

_____2. Nutrients like nitrogen and phosphorous occur naturally in ocean waters.

_____3. Problems with water quality affect the environment, but not the economy.

_____4. Both urban and rural areas contribute to environmental problems.

_____5. There is not much farmers can do to help prevent environmental problems thousands of miles away from them.

_____6. The government and private landowners need to work together to solve environmental problems.

After reading the articles, go back to your original responses to the statements. Did you change your mind about any of them? Jot down some notes here about how your answers may have changed. Then discuss with your nearest neighbor whether/how your responses changed before vs. after reading the articles.

SW.16.2.B.AS – Activity Worksheet

From Minnesota to the Gulf of Mexico: The Lethal Trickle Down Effect[9]

It's a problem the size of Massachusetts, and Minnesotans may be partially to blame.

More than 2,300 miles from its headwaters in northern Minnesota, the Mississippi River discharges water from 31 states and two Canadian provinces into the Gulf of Mexico. At the rate of up to 612,000 cubic feet per second, water pours into the Gulf - and along with it a host of additives that are creating a worrisome situation.

Gulf hypoxia is a condition in which excess nutrients in water lead to the creation of a dead zone - an area devoid of marine life. According to the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, in 2007, gulf hypoxia had resulted in a dead zone off the coast of Louisiana and Texas that was bigger than the state of Massachusetts.

"It's a large issue," said Brad Moore, commissioner of the Minnesota Pollution Control Agency Task Force. "Parts of 31 states contribute to the load."

"All rivers in the Mississippi River Basin contribute to the problem," said Terry Schwalbe with the Lower Minnesota River Watershed District.

However, it turns out the Minnesota River is a significant contributor to the problem. According to Moore, water originating in Minnesota makes up 7 percent of what enters the Gulf of Mexico. Of that percentage, the Minnesota River – which runs through huge tracts of agricultural land - accounts for 70 percent.

Algae populations

But why be worried?

Each summer, excess nutrients from cities and farm fields make their way into the Mississippi River and its water sources.

Those nutrients - mainly nitrates and phosphorus - provide a rich food source for algae. Algae populations bloom quickly and then die. Once they die, they sink to the bottom of the Gulf where oxygen in the water is consumed to decompose their bodies. Large algal populations deplete oxygen levels, making it difficult for other marine life to survive.

Hypoxia is a natural process, Moore admitted. It is usually resolved when hurricane season comes and stirs up the Gulf waters, but there are still plenty of reasons to be concerned. Hypoxic areas that were once showing up every few years now return to the Gulf of Mexico on an annual basis and they're getting bigger.

9 From the *Chaska Herald*, Chaska, MN, 07.17.08 - 04:29 pm
Article available online at: http://www.chaskaherald.com/view/full_story/13420314/article-From -Minnesota-to-the-Gulf-of-Mexico—The-lethal-trickle-down-effect?

SW.16.2.B.AS *(continued)*

"In the 1990s, (the size of the hypoxic zone) dramatically jumped," he said. "It doubled and we were worried it would cause an ecological breakdown."

Moore said the quality of the water entering the Gulf is "important to the livelihood and integrity of the ecosystem."

For example, sea life that cannot leave the area die while mobile creatures move further out into the ocean where oxygen is more plentiful. That forces commercial seafood operations to follow. Longer trips to catch fish and such mean higher prices at restaurants and grocery stores.

Education

And it all starts in the Mississippi River's home state.

"The consensus is we are contributing to it," said Moore.

"Everybody's downstream of someone else," said Scott Kudelka with the Minnesota River Watershed Alliance. "It's all about good stewardship."

The problem stems from both agricultural and urban run-off. Farmers use phosphorus and nitrates to grow their crops, which eventually find their way to the river. And in cities, growth spurs development meaning more land under concrete, which allows polluted water to run off rather than soaking back into the land.

"There's nothing stopping it," said Kudelka. "It doesn't collect in wetlands or forests when there are no wetlands or forests."

Several state and federal agencies are now working to get the word out about water quality and what can be done to improve it.

"We're trying to get everybody involved," said Kudelka. "Everybody contributes to pollutants."

"There's not enough money to correct the problem," said Schwalbe. "So we key in on education."

Kudelka said they try to tie in the problem on both local and global levels. Polluted water here can affect fishing and swimming, but the problem compounds further downstream.

Cities develop plans for storm water management. Environmental groups like the Friends of the Minnesota River Valley host clean up days. Farmers are encouraged to reduce their use of phosphorus and are given incentives to restore wetlands or create buffers between their farm fields and the river.

SW.16.2.B.AS *(continued)*

"We can't just hit them over the head with a hammer," said Moore. "We have to show practical solutions that will work for them. They're looking for more efficient ways to farm, too. They don't want to be wasting nutrients by sending them down river."

Progress

Local agencies are encouraged by the results of their efforts so far.

"There are a lot of people working on this," said Moore. "Progress is being made."

"Sediment and phosphorous levels are decreasing due to conservation efforts," said Kudelka.

The goal of the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force is to reduce the size of the hypoxic zone by two-thirds by 2015. It's an ambitious goal, Moore admits.

"The decision of the task force is to hold on to the goal and keep on target," he said. "Now we just have to be more accountable as to how we're going to get there."

That means more education, more outreach and more political lobbying. But locally, Schwalbe says he already sees a difference in the Minnesota River.

"I grew up in Chaska and I played in the rivers and streams," he said. "I see a much-improved river at times."

That may not mean much in the Gulf of Mexico, however. What effect this summer's floods along the Mississippi River might have on the hypoxic zone remains yet to be seen.

"We'll find out soon," said Wayne Anderson with the Minnesota Pollution Control Agency. "We'll do testing of the hypoxic zone in July but we anticipate that this year's will be larger than ever."

-Mollee Francisco, staff writer

SW.16.2.B.AS *(continued)*

What can you do at home?"

- Take care not to apply excess chemical fertilizer on your lawns.
- Compost lawn trimmings, branches and leaves instead of throwing them in the garbage.
- Create a rain garden with loose, absorbent soils and native plants to catch and hold rain water runoff from roofs and driveways.
- Purchase a rain barrel to catch runoff from roofs and use collected water for plants and gardens.

What can you do on the farm?

- Build wetlands, especially at the end of tile drains.
- Only apply as much fertilizer as is needed and when it is most beneficial
- Apply nutrients at the right rate by using soil tests and realistic yield goals, at the right time (as close to crop uptake as possible and by avoiding spreading just before a rain or snow or on frozen ground), with the right method (incorporating as soon after application as possible), and the right form

Source: Minnesota River Watershed Alliance and the Natural Resources Defense Council

SW.16.2.B.AS *(continued)*

Questions about *From Minnesota to the Gulf of Mexico: The Lethal Trickle-Down Effect*

1. How many states contribute water to the Mississippi River?

2. What is "Gulf Hypoxia?"

3. In two sentences, summarize the relationship between the Minnesota River and the Gulf of Mexico.

4. What are the primary nutrients of concern that end up in the Mississippi River, and where do they come from?

5. What is the role of algae in creating hypoxic conditions?

6. How is water quality in the Gulf related to people's livelihoods and ecosystem integrity?

SW.16.2.B.AS *(continued)*

7. What are the impacts of upstream elevated nitrogen and phosphorus levels?

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_____

8. How does agricultural run-off contribute to hypoxia in the Gulf? Urban run-off?

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_____

9. List two solutions that farmers have used to prevent hypoxia.

_____

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10. Give two examples of progress being made to prevent hypoxia around the Minnesota River.

_____

_____

11. Choose one example from the “What can you do?” section at the end of the article. Explain how this example can help to prevent hypoxia in the Gulf of Mexico and protect local and downstream drinking water quality.

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Answers to SW.16.2.B.AS *(continued)*

Answers about From Minnesota to the Gulf of Mexico: The Lethal Trickle-Down Effect

1. How many states contribute water to the Mississippi River?

   Parts or all of some 31 states

2. What is "Gulf Hypoxia?"

   Gulf hypoxia is a condition in which excess nutrients in water lead to the creation of a dead zone - an area where most marine life cannot survive due to a lack of available oxygen.

3. In two sentences, summarize the relationship between the Minnesota River and the Gulf of Mexico.

   - All rivers in the Mississippi River Basin contribute to the problem of Gulf hypoxia. However, it turns out the Minnesota River is a significant contributor to the problem.
   - 7 percent of the water that that enters the Gulf of Mexico originates in the State of Minnesota. Water from the Minnesota River, which runs through huge tracts of agricultural land, accounts for 70 percent of the 7 percent (or 5.4%) of the water that that enters the Gulf of Mexico.

4. What are the primary nutrients of concern that end up in the Mississippi River, and where do they come from?

   Mainly various forms of nitrogen and phosphorus compounds. Excess nutrients flow downstream from cities and farms into the Mississippi River and the Gulf of Mexico

5. What is the role of algae in creating hypoxic conditions?

   In the presence of excess nutrients, algae populations bloom more rapidly than they would under normal conditions, and then they die. Once they die, they sink to the bottom of the Gulf where oxygen in the water is consumed by the bacteria and other organisms that decompose the algae. Large algae populations deplete oxygen levels significantly, making it difficult for other marine life to survive.

Answers to SW.16.2.B.AS *(continued)*

6. How is water quality in the Gulf related to people's livelihoods and ecosystem integrity?

   Sea life that cannot escape the hypoxic area can die, while more mobile creatures, like fish and turtles, move further out into the ocean where oxygen is more plentiful. That forces commercial seafood operations to follow, meaning that they have longer trips to catch fish, which translates to higher prices at restaurants and grocery stores.

7. What are the impacts of upstream elevated nitrogen and phosphorus levels?

   Excess nitrogen runoff from farms, fertilized lawns and golf courses, and from sewage treatment plants and septic often results in elevated nitrate levels in drinking water, adding risk to public health and cost to consumers in order to effectively treat the drinking water. Increased nutrients like nitrogen and phosphorus also result in reduced access to recreational waters due to algae blooms, which can sometimes also produce toxins that have been shown to make humans and animals sick.

8. How does agricultural run-off contribute to hypoxia in the Gulf? Urban run-off?

   The problem stems from both agricultural and urban run-off. Farmers often use fertilizers, which can be in the form of chemical fertilizers or manure, to add essential nutrients to their soils and thus grow their crops. When fertilizer or manure is applied to the soil in excess of crop needs, or when it is applied on frozen or snow-covered ground or before precipitation, the excess nutrients can runoff to surface water or seep into groundwater. In developed areas, sources of nutrients can include fertilizer on lawns and golf courses, and septic systems and sewage treatment plants.

9. List two solutions that farmers have used to prevent hypoxia.

   Cities develop plans for storm water management, including separating pipes for storm drains and sewers. Developing areas can protect sensitive areas from development or siting of potential sources of contamination, such as concentrated areas of septic systems, and can incorporate low impact development techniques to reduce runoff. Environmental groups like

Answers to SW.16.2.B.AS *(continued)*

the Friends of the Minnesota River Valley host clean up days. Farmers are encouraged to reduce tillage, and to use best conservation practices when applying fertilizer and/or manure:

a. Rates: Apply only the amount of nutrients needed to grow crop based on realistic yield goals and soil tests.

b. Timing: Apply nutrients as close as possible to the period of rapid crop uptake. Do not apply nutrients on snow covered/frozen/ saturated ground, or before a rain.

c. Method: Incorporate nutrients into the soil as soon as possible after application while disturbing as little soil as possible.

d. Form or type of fertilizer: Choose nitrogen sources that are more likely to be held in the soil. USDA and some states offer incentives, including cost-share programs, to implement conservation practices, to protect surface water such as streams and rivers or groundwater sources, or take vulnerable land out of crop production.

10. Give two examples of progress being made to prevent hypoxia around the Minnesota River.

    Sediment and phosphorous levels are decreasing due to conservation efforts.

    Continued commitment to the goal to reduce the hypoxic zone by two-thirds by 2015, and more education and outreach.

11. Choose one example from the “What can you do at home?” section and one example for the “What can you do on the farm?” section at the end of the article. Explain how these examples can help to prevent hypoxia in the Gulf of Mexico, and protect local and downstream drinking water quality.

SW.16.2.C.AS – Activity Worksheet

Gulf Coast Program Awards Iowa[10]

Farmers reduce fertilizer runoff in Mississippi

NEW ORLEANS — Iowa isn't so far from Louisiana when it comes to water quality, representatives from the agriculture community say.

"We're all interconnected," said Bill Northey, Iowa's Secretary of Agriculture.

Northey, and others from Iowa, were in New Orleans this week to accept an award from the Gulf of Mexico Program for work they've done to reduce the amount of nutrients that get into water draining into the Mississippi River.

The Iowa group was recognized for its work in reducing nutrients — primarily nitrogen — that runs off farmland through underground drainage systems.

These "tile drains" make more land farmable, but they contribute about 90 percent of the nitrogen load leaving Iowa for the Mississippi River, said Dean Lemke, with the Iowa Department of Agriculture.

Nutrients from farm and urban sewer systems flow down the Mississippi River and into the Gulf of Mexico. There, the nutrients feed small organisms that use up oxygen in the lower depths of the Gulf of Mexico, creating an annual summer "dead zone," also known as hypoxia.

The Iowa partnership used federal funds and voluntary farmer participation to build wetlands at the end points of some tile drainage systems, Lemke said.

The wetlands use the nitrogen and can prevent between 40 and 90 percent of the nitrogen from fertilizer from getting into nearby water bodies and eventually the Mississippi River, he said.

To get that kind of reduction, the wetland needs to be between 0.5 percent and 2 percent of the size of the land being drained into it, Lemke said.

It's estimated that 75 wetlands created in Iowa would remove 54,000 tons of nitrates from the water drained from 86,000 acres during a 150-year period, he said.

The first wetland in the program was built in 2003, and 72 have either been built or are in the process of being built or designed, Lemke said.

10 By Amy Wold, Advocate staff writer, Published: Nov 2, 2008, From The Advocate, Baton Rouge, LA
Article available online at: http://www.2theadvocate.com/news/33704834.html?index=1&c=y

SW.16.2.C.AS *(continued)*

"It's been popular with Iowa landowners. We have a waiting list of people who are waiting to go if we can find the money," Lemke said.

Rick Robinson of the Iowa Farm Bureau added that the difference between the number of landowners who want to join the program and the money available is between $25 million and $100 million a year.

The program is a partnership between the Iowa Department of Agriculture and Land Stewardship, Iowa Farm Service Agency and the Iowa Farm Bureau Federation with funding from the state and the federal Conservation Reserve Enhancement Program.

The $38 million program — funded with 80 percent federal funds and a 20 percent state match — provide incentives to farmers to put some of their land into wetland creation, said John Johnson, deputy administrator for farm programs with the U.S. Department of Agriculture in Washington, D.C.

Incentives and payments to farmers are important because wetlands provide benefits to society as a whole, so the cost of taking land out of production shouldn't be the farmers' burden to bear, Johnson said.

While in New Orleans to accept the award, the Iowa agriculture representatives, during a boat tour Thursday, got a chance to see what Louisiana is doing to reduce the Gulf of Mexico dead zone.

DEQ staff took the Iowa representatives to see the Caernarvon Freshwater Diversion project, which takes Mississippi River water into marshes below New Orleans.

In addition, there was discussion about using wetlands in a way that is similar to an Iowa program that puts treated sewer effluent into created marshlands to help clean out nutrients.

SW.16.2.C.AS *(continued)*

Questions about *Gulf Coast Program Awards Iowa*

1 .What is the major source of the nitrogen load leaving Iowa for the Mississippi River?

2. How have farmers been working to prevent nitrogen from entering the Mississippi River?

3. Why are wetlands effective in preventing nitrogen from entering the river?

4. Assume that 75 new wetlands are constructed along the length of a stream. By about how much would those wetlands reduce nitrate delivery downstream?

5. What has been the response of landowners to the Iowa Partnership Program?

SW.16.2.C.AS *(continued)*

6. Why don't greater numbers of landowners participate in the program?

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_____

7. Who are the partners involved in making this program work?

_____

_____

8. If you were an Iowa farmer, would you be interested in participating in this program? Why or why not?

_____

_____

POWERPOINT SLIDES – AS NEEDED:

SW.16.1.TM

The Mississippi River Basin and the Hypoxic Zone

SW.16.2.TM

Wetlands[11]

Wetlands are areas where:

- Water covers the soil or is present either at or near the surface of the soil for all or part of the year.
- Saturation largely determines how the wetland soil develops and the types of plant and animal communities living in and on the soil.
- Both aquatic and terrestrial species are usually supported by wetlands.
- The prolonged presence of water favors specially adapted plants and animals, and promotes the development of characteristic wetlands soils.

11 Adapted from http://water.epa.gov/type/wetlands/types_index.cfm