**Activity Title:** Fertilizer use and its effects on the Gulf of Mexico.

**Subject (Focus/Topic):** This activity focuses on the effects of excess nutrients, such as nitrogen and phosphate, entering into the Gulf of Mexico via the Mississippi River basin.

**Grade Level:** 9-12 grades

**Average Learning Time:** Approximately one week but can be adapted for a shorter duration of time.

**Lesson Summary (Overview/Purpose):** Students will learn about the nitrogen and phosphorus cycles and how human impacts on these cycles are altering the ocean and its inhabitants.

**Overall Concept (Big Idea/Essential Question):**

- Students will learn about the nitrogen and phosphate cycles.
- Students will learn how humans are impacting these cycles and its effects on the ocean.
- Students will learn about the importance of dissolved oxygen and how it's affected by biotic and abiotic factors.
- Students will be able to explain the hypoxic conditions in the Gulf of Mexico using their understanding of biogeochemical cycles and dissolved oxygen.
- Students will design a plan of action or engineer a product that will help solve this environmental problem.

**Specific Concepts (Key Concepts):**

- Students will understand that humans are impacting the biogeochemical cycles on our planet.
- Students will be able to explain the cause of hypoxia and its effects on ocean life.
- Students will understand that it is up to us to think of solutions and design products that can help solve the problems we are unintentionally creating on our planet.

**Focus Questions (Specific Questions):**

- What are the nitrogen and phosphorus cycles?
- What happens to excess nutrients that are placed on lawns and crops?
- How can these excess nutrients cause a problem?
- What is dissolved oxygen?
- What are some biotic and abiotic factors that can affect DO levels in the ocean?
- What are hypoxic conditions?
- How does hypoxia affect the ocean ecosystem?
- How can we help prevent hypoxia?

**Objectives/Learning Goals:**

- Students will be able to draw a diagram of both the nitrogen and phosphorus cycles. Reservoirs will be labeled and arrows will be used to show how the elements travel. Students should be able to label at least nine out of twelve reservoirs for the nitrogen cycle and all of the reservoirs of the phosphorus cycle.
- Students will be able to explain the importance of dissolved oxygen and will be able to name two biotic and two abiotic factors that affect the levels of DO.
- Students will be able to synthesize an essay, video report, Glog or Viocethread explaining the hypoxic conditions in the Gulf of Mexico using their understanding of biogeochemical cycles and dissolved oxygen.
- Student teams will create an action plan or engineer a product that will help address the hypoxic conditions in the Gulf of Mexico. Action plans must be realistic so they could be sent in letter format to a Congressman if desired. The product

designs and/or prototypes will be explained and demonstrated to the class for peer review.

**Background Information:** Nitrogen and phosphorus are essential elements for every living thing on the planet. Without these nutrients living things would not be able to make proteins, DNA, RNA, energy, bones or other body tissues. The nitrogen cycle and phosphorous cycle are the paths these chemicals take when traveling between living things and their environments (biogeochemical cycles).

Our atmosphere is approximately 78% nitrogen (N2), but plants and animals are unable to use nitrogen unless it has been turned into a compound such as ammonia (NH4) or nitrate (NO3). Taking nitrogen gas and changing it into a usable form is called nitrogen fixation. The few things on our planet that can fix nitrogen into a usable form are lightning, bacteria that live on the roots of legumes (peas, clover, alfalfa, etc.) and soil bacteria. These things fix nitrogen naturally where it will end up in the soil so it can be utilized by plants. Animals then eat the plants and the elements get passed through the food wed. With advances in agriculture and more demand for food, humans have devised a way to fix nitrogen artificially for use in fertilizers.

Here is a good activity to introduce your students to the nitrogen cycle
http://www.windows2universe.org/teacher_resources/teach_nitrogen.html

Unlike other biogeochemical cycles, the phosphorous is not found in the atmosphere. Phosphorous originates in the lithosphere and is released through the weathering of rocks. Erosion carries the element away and it ultimately gets absorbed by plants. Like nitrogen, phosphorous is a limiting nutrient so humans have devised a way to put the element into fertilizers for better plant growth.

Farmers, cities and homeowners apply these chemical fertilizers to their crops, lawns and gardens. Precipitation and irrigation can cause these chemicals to run-off into local streams or rivers which will eventually lead into the ocean. The Mississippi River Basin covers more than 40% of the United States including the areas of greatest agricultural productivity. As the Mississippi River empties into the Gulf of Mexico it carries much of the excess nutrients with it.

Nutrients such as nitrogen and phosphorus encourage the production of plants on land and in the water. These excess nutrients (eutrophication) cause algae to grow out of control and disrupt the natural ecosystem. As these plants die, bacteria decompose the plant tissue while consuming the oxygen in the water. As the populations of bacteria grow, the amount of oxygen continues to decline. If dissolved oxygen levels get low enough (below 2ppm) the waters become hypoxic and can no longer sustain life.

**Common Misconceptions/Preconceptions:** Clarify that nitrogen and phosphorus are not living things, but rather essential elements that are needed for living things to survive.

Matter such as nitrogen and phosphorus are continually cycled on our planet and changed from one form to another.

Every action we make has an effect, positive or negative, on the environment.

Many people believe the ocean is too big for us to impact.

**Materials:** NA

**Technical Requirements:** Computer lab for research and projects.

Overhead projector for showing video clips and presentations of Glogs.

Video recorders for students that choose the video report.

**Teacher Preparation:**

Print off the nitrogen cycle game stations and passport logs. Gather dice, if playing the nitrogen cycle game mentioned earlier.

Sign up for a Glogster account (http://www.glogster.com/) and/or Voicethread account (http://ed.voicethread.com/) so students can

showcase their understanding of hypoxia in the Gulf using a multimedia project.

Create grading rubrics for student projects.

**Keywords:** eutrophication, hypoxia, dissolved oxygen (DO), run off, biogeochemical cycles

**Pre-assessment Strategy/Anticipatory Set (Optional):** Ask students how we have been able to continue feeding the growing number of people on our planet. Many students will respond with advances in agriculture. Ask what kinds of consequences could come from these actions. Then play the following clip from NOAA News:

Happening Now: Dead Zone in the Gulf http://oceantoday.noaa.gov/happnowdeadzone/

**Lesson Procedure:**

1. After the Anticipatory Set introduce students to the term biogeochemical cycle.
2. Teach students about the nitrogen and phosphorus cycles.
3. Educate students about dissolved oxygen and the factors that can affect its concentrations.
4. Explain to students that they are going to research how humans are impacting these nutrient cycles so they can put together a digital presentation (or essay) about hypoxia in the Gulf of Mexico.
5. Give students the following sites to help them with their research.
6. NOAA's Hypoxia Watch http://www.ncddc.noaa.gov/hypoxia/
7. Gulf of Mexico Teacher at Sea Blog http://teacheratsea.wordpress.com/category/noaa-teacher-at-sea-2/heather-haberman/
8. NOAA's iGulf http://igulf.noaa.gov/
9. NOAA Education Resources http://www.education.noaa.gov/
10. After students have presented their projects, give them some time to work in teams to develop an action plan or design a product that could help us solve the problems we are facing with hypoxic waters.
11. Students should send their action plans to a Congressman and/or create a prototype of their product for display.

**Assessment and Evaluation:**

1. Students should be able to demonstrate their understanding of the nitrogen and phosphorus cycles by drawing a complete diagram of a cycle. Create a rubric for the diagrams.
2. Student multimedia projects (or essays) should demonstrate a clear understanding of how excess nutrients lead to hypoxia, how DO is affected by these conditions, the effects of hypoxia on an ecosystem and what should be done about the problem. If creating a rubric, be sure to leave enough room for student creativity and logical thinking.
3. Student action plans and/or products should be logical, professional and well thought out.

**Standards:**

- **National Science Education Standard(s) Addressed:**

Science as Inquiry

Structure and properties of matter

Geochemical cycles

Abilities of technological design

Understanding about science and technology

Personal and community health

Population growth

Environmental quality

Natural and human-induced hazards

Science and technology in local, national, and global challenges

Nature of scientific knowledge

Science as a human endeavor

- **Ocean Literacy Principles Addressed:**

g The ocean is connected to major lakes, watersheds and waterways because all major watersheds on Earth drain to the ocean. Rivers and streams transport nutrients, salts, sediments and pollutants from watersheds to estuaries and to the ocean.

c Erosion—the wearing away of rock, soil and other biotic and abiotic earth materials—occurs in coastal areas as wind, waves, and currents in rivers and the ocean move sediments.

f Ocean habitats are defined by environmental factors. Due to interactions of abiotic factors such as salinity, temperature, oxygen, pH, light, nutrients, pressure, substrate and circulation, ocean life is not evenly distributed temporally or spatially, i.e., it is “patchy”. Some regions of the ocean support more diverse and abundant life than anywhere on Earth, while much of the ocean is considered a desert.

e Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (point source, non-point source, and noise pollution) and physical modifications (changes to beaches, shores and rivers). In addition, humans have removed most of the large vertebrates from the ocean.

g Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.

- **State Science Standard(s) Addressed:** Nebraska State Science Standards

12.1.2 Students will apply the nature of scientific knowledge to their own investigations and in the evaluation of scientific explanations.

12.1.3 Students will solve a complex design problem.

12.3.3 Students will describe, on a molecular level, the cycling of matter and the flow of energy between organisms and their environment.
12.4.2 Students will investigate the relationships among Earth's structure, systems, and processes.

- **Other National or State Standards Addressed (Optional)**

**Additional Resources:** All listed in the lesson.

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