Can Nutrients in Water Cause Harm?

from *The Science of Water Teacher's Guide* and for *Mystery of the Muddled Marsh*

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BioEd℠

Teacher Resources from the
Center for Educational Outreach at
Baylor College of Medicine

Third edition. First edition published 1997.
Printed in the United States of America

ISBN: 978-1-888997-61-3

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The activities described in this book are intended for school-age children under direct supervision of adults. The authors and Baylor College of Medicine cannot be responsible for any accidents or injuries that may result from conduct of the activities, from not specifically following directions, or from ignoring cautions contained in the text.

Development of this unit was supported, in part, by grant numbers R25 ES06932 and R25 ES010698 from the National Institute of Environmental Health Sciences (NIEHS) of the National Institutes of Health (NIH). The opinions, findings and conclusions expressed in this publication are solely those of the authors and do not necessarily reflect the official views of Baylor College of Medicine, NIEHS or NIH.

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ACKNOWLEDGMENTS

The Science of Water educational materials, first developed as part of the My Health My World® project at Baylor College of Medicine, have benefited from the vision and expertise of scientists and educators representing a wide range of specialties. Our heartfelt appreciation goes to Michael Lieberman, M.D., Ph.D., William A. Thomson, Ph.D., and Carlos Vallbona, M.D., who have lent their support and expertise to the project.

Special acknowledgment is due to our original partners in this project, the Texas Medical Association and the American Physiological Society (APS). We especially thank Marsha Lakes Matyas, Ph.D., of APS, for her direction of field test activities and ongoing collaboration.

Several colleagues provided valuable assistance during the development of this guide. In particular, we would like to thank Cassius Bordelon, Ph.D.; Zenaido Camacho, Ph.D.; Ronald Sass, Ph.D.; Saundra Saunders, M.A.; Linda Thomson, M.A.; Cathey Whitener, M.S.; Ellison Wittels, M.D.; and Rosa Maria Ynfante, B.S.

Special thanks go to the National Institute of Environmental Health Sciences, Allen Dearry, Ph.D., Frederick Tyson, Ph.D., and Liam O'Fallon, for their support of the My Health My World project and the related Environment as a Context for Opportunities in Schools (ECOS) project.

We are especially grateful to the many classroom teachers in Washington, D.C., and Houston and Austin, Texas, who participated in the field tests of these materials and provided invaluable feedback.

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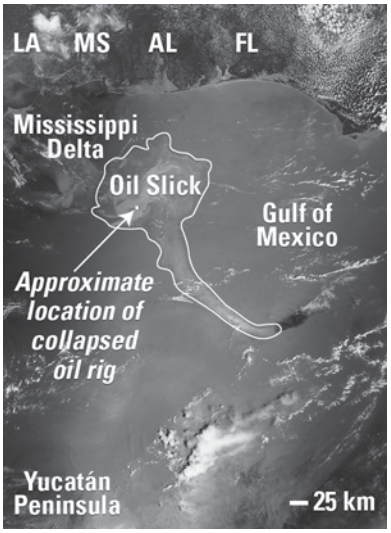
Water Pollution and Health

Environment and Health Basics

All the water on Earth ultimately forms a single, immense system. Oceans, wetlands, streams, lakes and underground water supplies all are linked through drainage patterns in watersheds and through the endless cycling of water on our planet. Because water sources are connected, pollutants travel from part of one ecosystem to another. Eventually, the contaminants can affect very distant ecosystems and populations. Water pollutants can be divided into several major categories, all of which impact human health and well-being.

- **Nutrients.** These can come from chemical sources (fertilizers or detergents) or can be biological in origin (sewage or manure). Nutrients usually are carried into water sources by rainwater. They cause excessive growth of water plants and algae, which can clog navigable waterways and consume oxygen (needed by other organisms such as fish) when they decompose. These changes cause the decline of important lakes and wetlands, and can affect the quality of drinking water. In groundwater, fertilizers can make water from wells unsafe to drink.
- **Soil and sand from plowed fields, construction sites, logging sites, urban lands and areas being strip-mined.** These sediments make lakes, wetlands and streams more shallow, limiting the use of waterways for transportation and decreasing the quality of wildlife habitats. Washed-off soil also can be a source of excess nutrients.
- **Disease-causing organisms.** Bacteria, viruses and single-celled parasites can enter water supplies from inadequately treated sewage, storm water drainage, septic systems, livestock pens, and boats that dump human wastes. These organisms cause diseases such as dysentery and typhoid, and skin and respiratory illnesses.
- **Metals (such as mercury and lead) and toxic chemicals (such as those found in pesticides, herbicides, cleaning solvents, plastics and petroleum derivatives).** These substances can be poisonous to humans and wildlife. Metals and many manufactured chemicals persist in the environment. They build up in the bodies of fish and other animals, and can find their way into groundwater, making it unsafe to drink.
- **Heat.** Warm water discharged from power plants (where water is used for cooling) can drastically alter aquatic ecosystems. Changes in water temperature can affect the quantity of oxygen in the water and can make some organisms more susceptible to disease, parasites and toxic chemicals.

Most sources of water pollution are spread over large areas. Water from rain and irrigation collects pollutants as it washes over the land or sinks into the soil. This type of pollution, which is not attributable to a single location, generally is called non-point source pollution. It is much more difficult to monitor and to control than point source pollution—which is discharged at a single place (such as from a factory or waste treatment plant, or a chemical spill).



A large patch of oil visible near the site of the *Deepwater Horizon* rig collapse and oil spill on May 17, 2010. A long ribbon of oil stretches far to the southeast, entering the loop current, a stream of fast moving water that circulates around the Gulf of Mexico before bending around Florida and up the Atlantic coast.

Source: NASA Earth Observatory.

WATERSHEDS

An area of land that catches rain and snow and drains into a marsh, river, lake, groundwater or other body of water is called a watershed. Watersheds come in all sizes, and they form based on water drainage patterns. Within watersheds, water always flows downhill—so any activity that changes characteristics of water upstream will affect water quality downstream. Homes, farms, cities, fields and forests all can be part of the same watershed.

Satellite image courtesy of NASA Earth Observatory.

Can Nutrients in Water Cause Harm?

CONCEPTS

- Many different kinds of organisms live in water.
- Excess nutrients will cause over-abundant growth of some organisms living in water.
- Non-point source pollution is a major threat to water supplies in the United States.

OVERVIEW

Students create pond water cultures and investigate the effects of adding chemical or natural nutrients.

SCIENCE, HEALTH & MATH SKILLS

- Measuring
- Predicting
- Observing
- Drawing conclusions

TIME

Preparation: 30 minutes
Class: Three 30-minute sessions

MATERIALS

- 3 clear, 2-liter soft drink bottles,
- Hay (or dried grass), 2 oz
- Small container of fish food
- Small container of liquid fertilizer
- Spring water, gal (or tap water without chlorine, see SETUP)

Each student will need:

- Copy of "My Marsh Observations" page

In general, two types of sources contribute to water pollution in the United States. Point sources, such as factories, sewage treatment plants, abandoned mines and oil tankers, introduce pollutants into waterways at single places. This type of pollution is not always significant in terms of volume, but it is the major point of entry for toxic chemicals into water supplies. In most cases, point sources of pollution can be identified and monitored by government agencies.

Non-point source pollution occurs across large areas of land that drain into underground and surface water sources. Pollutants are collected and deposited by water as it travels over land and through layers of soil. Major contributors to non-point source pollution include agricultural activities (which can add chemical fertilizers, pesticides, manure and soil to water), logging and other activities that leave the soil surface bare (allowing soil to be washed into waterways), urban and suburban areas (where lawn chemicals, household chemicals, motor oil and gasoline can enter water supplies), and septic systems (which can contaminate underground water supplies with disease-causing bacteria). Non-point sources of water pollution are difficult to control because they are spread over large areas, and often result from the actions of many individuals.

Unit Links

Mystery of the Muddled Marsh
Science boxes, pp. 10 and 21

Explorations
We Can Make a Difference, p. 6

In the story, *Mystery of the Muddled Marsh*, which accompanies this unit, runoff from a new park development introduces soil and fertilizers into a marsh and stream ecosystem. Excess soil and fertilizers lead to murky water and overgrowth of plants, green algae and some microorganisms in the marsh, threatening the marsh animals and their habitat. Riff and Rosie (characters in the story) are able to connect development of the park to changes that they have observed in the marsh.

In this activity, students investigate, on a small scale, the changes that occur when fertilizers are added to pond water cultures.

SETUP

You will need to use a hay infusion kit (or pond water) to carry out this activity. Hay infusion kits may be ordered from science education supply companies. Set up your hay infusion culture in a two-liter bottle about one week before beginning the activity. Use one gallon of spring water (or let the same amount of tap water rest uncovered for 24 hours).

As an alternative to creating your own "pond water" by means

of a hay infusion kit, you may use water that you or your students have collected from a pond, ditch or stream. In this case, try to find water that has bits of green algae floating in it.

You also will need three clear 2-liter plastic soft drink bottles. Cut the tops off the bottles to make cylindrical containers.

Conduct this activity as a class demonstration. Have each student record his or her own observations on the "My Marsh Observations" sheets.

PROCEDURE

Session 1: Set up pond water cultures

1. Begin by asking students if they remember what happened to Marigold Marsh in the story, *Mystery of the Muddled Marsh*. Allow time for everyone to share his or her ideas. Then, tell students that they will be able to see some of the tiny plants and animals that lived in the muddled marsh while they conduct an investigation of what happens when fertilizer is added to a water ecosystem.
2. Have one or two students label the three bottles "NF" (no fertilizer, or control), "N" (natural fertilizer), and "C" (chemical fertilizer). In bilingual classrooms, label the containers "SF" (sin fertilizante), "N" (fertilizante natural), and "Q" (fertilizante químico).
3. Show students the prepared (or pond) water. If possible, put a few drops of the water under a microscope for students to observe. Explain that they will be growing similar living things in the bottles. Add about 250–500 mL of the hay infusion or pond water, along with some hay/dried grass, to each bottle.
4. Set the soft drink bottles in a bright window or under bright fluorescent lights for 1–2 days to allow the culture to develop. (In conditions with low light, hay infusions will tend to develop mold and/or foul smelling bacteria within 2–3 days.)

   Note. If using pond water that already has plenty of green algae and other growth, proceed directly to the next step without resting the cultures.

Session 2: Beginning the experiments

1. Allow time for groups of students to observe the three bottles. Each student should record his or her own observations. Ask, *Do you notice any differences among the bottles? Why or why not?* Have students observe the water using a hand lens or microscope.
2. Explain to the students that they will investigate what happens when nutrients, in the form of fertilizer, are added to aquatic ecosystems. Most students will be familiar with the word "fertilizer" from the story, *Mystery of the Muddled Marsh*. Make sure that they understand that fertilizer has good

Continued

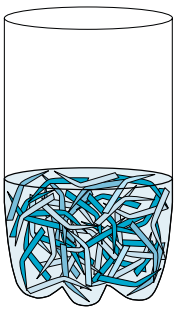
Dyke Marsh (above), a tidal marsh on the west bank of the Potomac River south of Alexandria, Virginia, is a mixture of fresh water and salt water. The water and plants are not only adversely affected by contaminants already in the fresh water and salt water, but also by shoreline erosion and surface runoff.

The marsh water also is used by and affects animals living in this ecosystem. The animals which include beavers, bats, birds, foxes, muskrats, rabbits, squirrels, shews and field mice.

Source: U.S. National Park Service.

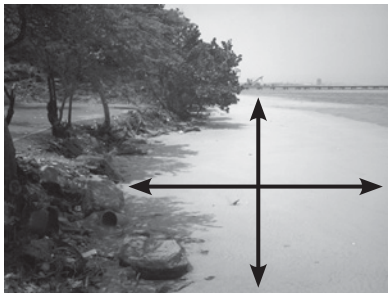
If possible, obtain a microscope and allow students to observe some of the minute organisms present in the pond water.

Students observe the effects of adding nutrients to a water community (see SETUP).



applications and that it can be very important for food production.

3. Show the chemical fertilizer and fish food to the class. Help the students understand that both substances will add nutrients to the water in the bottles.
4. Ask one student to add three drops of liquid fertilizer to the bottle labeled "C," and another student to add a large pinch of fish food to the bottle labeled "N." Have students predict what will happen in each bottle over the course of the next week. The bottles should be kept in a bright window or under bright fluorescent lights.



The area marked with arrows is an algal bloom in a Venezuelan lagoon. The bloom, combined with pollution, resulted in eutrophication of the water.

Eutrophication is when large amounts of nutrients are present in lakes, streams or the ocean. Algae and other microscopic organisms may grow so abundantly that they choke out other water life. The algal growth blocks sunlight. This causes underwater plants, which provide food and shelter for many animals, to die. In addition, when the algae begin to die and decompose, dissolved oxygen needed by fish and other animals is used up. This process occurs naturally over hundreds or thousands of years in some aquatic ecosystems. However, human activities accelerate eutrophication by increasing the rate at which nutrients enter bodies of water.

Session 3: Looking at results

1. Have students observe the bottles every day and write or draw their observations on their student sheets.
2. After about a week, have students discuss their results within small groups. Have them compare the appearance of the three bottles. Ask, *Which bottle has the cloudiest water? Which bottle has the clearest water?* Students also may be able to observe differences in water color and/or the amount of organisms in their bottles. Older students may want to compare the amount of organisms in a drop of water from each bottle. In general, expect the bottles with chemical and natural fertilizers to grow more algae and other microorganisms. Given enough time, these cultures may turn brown and develop a foul smell.
3. Discuss the results with the class. Ask, *What happened when we added more nutrients to the water in the bottle? What do you think will happen if we continue to add more nutrients to the bottles?* Help the students make extensions to other situations by asking, *What can we do to reduce the amount of fertilizer that washes into lakes and streams? What would happen if no one used fertilizers at all? Can you think of ways we can use the fertilizer we need to grow food without polluting our waterways?*

VARIATIONS

- Visit a nearby stream, marsh, or ditch with standing water and let students collect small samples of water. Have students observe their water samples in class using hand lenses or low-power microscopes. Students should compare what they see to their observations of the water in the soft drink bottles.
- Keep one or more cultures of pond water alive in the classroom for longer periods of time by aerating the culture with a simple aquarium pump and plastic tubing inserted into the water.
- Have student groups set up their own cultures and investigate the effects of one or both kinds of fertilizers on their systems.

Photo of lagoon by Wilfredo R. Rodriguez H., Wikimedia Creative Commons 2.5.

My Marsh Observations

Write or draw your observations in the boxes below.

Name _____

Date _____

NF	N	C
No fertilizer	**Natural fertilizer (fish food)**	**Chemical fertilizer**

Date _____

NF	N	C
No fertilizer	**Natural fertilizer (fish food)**	**Chemical fertilizer**

Mis observaciones del pantano

Escribe o dibuja tus observaciones en los cuadros.

Nombre _____

Fecha _____

SF	N	Q
Sin fertilizante	**Fertilizante natural (alimento para peces)**	**Fertilizante químico**

Fecha _____

SF	N	Q
Sin fertilizante	**Fertilizante natural (alimento para peces)**	**Fertilizante químico**