Extension: Impure water is bad for ecosystems, bad for people too.

Nutrients such as nitrogen and phosphorus are necessary for plant growth. Look at what is in MiracleGro or any other commercial plant food! Excess nutrients getting into lakes and streams can be very harmful, however. They cause algae and other water plants to grow like crazy, to overpopulate the water body, and, when they die and sink, to use up all of the oxygen in the water by decomposing (technical term: rotting). Fish and other water animals need oxygen in the water to breathe. Without it, they too will die. When excess nutrients pollute the water, it is known as eutrophication ("YOU troh fih CAY shun"). Water from these eutrophic systems smells bad, tastes bad, and can even be unhealthy for human consumption.

In the Mississippi River, nitrate concentration has more than doubled since 1965. The resulting eutrophication in the Gulf of Mexico is depleting oxygen in the bottom waters, a condition known as hypoxia ("hi POX ee ah"). The northern Gulf of Mexico is now the site of the largest zone of hypoxia in the Western Hemisphere. Unfortunately, it coincides with some of the nation's most important fishing waters. In 1998, the Gulf hypoxic zone was about the size of Connecticut.

Many birds and other wildlife depend on fish for food. When the food web is messed up by eutrophication and hypoxia, there are consequences for many other animals. These consequences can be hard for people to predict, because we do not yet fully understand the complexities of food webs.

You can do a windowsill experiment in your classroom to illustrate how eutrophication works. Fill two clear glasses with water and put a small amount of plant food into one of them. Cover both to reduce evaporation. Check on the glasses every few days and record what you see. When did green stuff start to appear in the fertilized water? The unfertilized water? Is most of it growing on the glass, or in the water itself? Where did the algae in this water come from? (This latter question is particularly interesting to students if you took water from the tap).

Excessive nutrients come from fertilized lawns, golf courses, animal waste, agricultural fields, and other sources. Eutrophication and hypoxia are only two of the negative consequences. Too much nitrogen can also result in acidification of water and soils, leading to long-term changes in plant and animal communities. These changes can, in turn, result in a loss of the natural biological diversity of the ecosystem, which leads us back to ecosystem services.

When ecosystems lose diversity of plant, animal, and microbial life forms, they often no longer provide the same level of service that humans have come to depend upon. A river can purify a certain amount of pollution for the people living along it, and still provide clean drinking water for downstream communities. But when it gets too much pollution

to handle, it can no longer provide this service, and the folks downstream have to pay more to have their drinking water cleaned and purified.

The World Resources Institute's **EarthTrends** (http://earthtrends.wri.org) website includes succinct and up-to-date information on the sources and consequences of water pollution. From the Earthtrends home page, click on "Water Resources and Freshwater Ecosystems" and select "Features." Then click on "Dirty Water: Pollution Problems Persist." Explain to your students that all of the inputs to waterways are either point source (i.e. a discharge pipe) or non-point source (i.e. runoff). Ask them to guess what percentage of nutrient pollution comes from point vs. non-point sources. Then check out the answer in Figure 2 of the "Dirty Water" article. You might be surprised. I was!

The Council for Agricultural Science and Technology is the source of a comprehensive article on **Gulf of Mexico Hypoxia** (http://www.cast-science.org/pdf/hypo.pdf), for advanced students who may be interested in pursuing this topic a little further.

Ecosystems are not the only things damaged by excess nutrients. Humans are also harmed by too much nitrogen in their drinking water. "Blue baby" illness in infants is due to the conversion of nitrate to nitrite by the body, which can interfere with the oxygen-carrying capacity of the child's blood. The child's health can deteriorate rapidly over a period of days and the condition can be fatal. Symptoms include shortness of breath and blueness of the skin.

Many people think of pollution as primarily an urban problem, but nitrate is one of the most common groundwater contaminants in rural areas. Nitrate in groundwater comes from fertilizers, septic systems, and manure storage or spreading operations. Although nitrate levels that affect infants do not pose a direct threat to older children and adults, they do indicate the possible presence of other more serious residential or agricultural contaminants, such as bacteria or pesticides.

The **Natural Resources Cornell Cooperative Extension** (http://pmep.cce.cornell.edu/facts-slides-self/facts/nit-heef-grw85.html) service provides an excellent site with background information on nitrate in groundwater.

Nutrients are a common and increasing problem, but poisons in the water are still a serious concern despite decades of environmental cleanup efforts. The Environmental Protection Agency (EPA) estimates that about one third of all of the waters assessed by individual state agencies are unsafe for swimming, fishing, and drinking. In 1997, there were nearly 2,200 fish consumption advisories in effect in the U.S. (in 47 states) due to contaminants in lakes and rivers, including mercury, PCB's, chlordane, dioxin, and DDT.

Certain chemicals in water tend to bind to particles and collect in bottom sediments. When present at elevated levels in sediments, chemicals can kill or harm bottom-dwelling organisms. Pollutants in sediments can also accumulate in aquatic organisms and move up the food chain to fish, shellfish, and eventually humans.

Take your students on an exploration of the EPA's **Index of Watershed Indicators** (http://www.epa.gov/iwi/national/) to see where in this country we have the biggest problems.

Human health and safety is also threatened by pathogens in the water. More than 100 types of human pathogenic viruses may be present in fecal-contaminated waters. *Giardia*, an intestinal parasite that is difficult to remove from source water, is found in waters receiving urban pollution. Where watersheds are protected and natural water purification is undisturbed, there are lower concentrations of *Giardia* and other dangerous pathogens such as E. coli, salmonella, and the protozoan *Cryptosporidium*, in the water. In 1993, *Cryptosporidium* infiltrated public water systems, causing 400,000 cases of diarrhea and numerous deaths in Milwaukee.

Today, Americans consume over three and a half billion gallons of treated water every day. There are nearly 250,000 public water supply systems in the United States, serving everything from the smallest towns to major metropolitan centers. Ninety percent of the population receives its water through these community water systems, with the rest using private wells or other individual sources.

The Environmental Protection Agency (EPA) ranks drinking water pollution as one of the top four environmental threats to health. Internationally, where over a billion people lack clean drinking water and almost two billion lack sewage systems, waterborne microbial disease presents perhaps the world's single largest environmental health risk, afflicting more than a billion people and killing millions each year.

With the introduction of filtration and disinfection systems during the last century, the risk of disease from drinking water in wealthier countries has been substantially reduced. Despite the enormous progress that has been made, however, there are still significant numbers of disease cases resulting from contaminated drinking water in the United States. Health risks from aquatic pathogens range from mild gastrointestinal distress to systemic disease and, in severe cases, death. Additional information on waterborne disease and disinfection can be found at the Chlorine Chemistry Council site, on the Chlorine Saves Lives (http://c3.org/chlorine_knowledge_center/12749.html) page.