Water Quality Monitoring

Whether using simple, inexpensive field test kits, or more expensive probes and meters, your students can gather data about water quality that will help them learn a tremendous amount about the rivers, streams, bays, and other water bodies that they see everyday. Students can use monitoring equipment and apply scientific process skills as they gather data about many parameters of water quality. By assessing the water quality in a local water body, students will better understand how human activities are affecting this resource, and how we can protect water quality in the future.

Water Pollution – Any physical, chemical, or biological change in water quality that has a harmful effect on living organisms or makes water unsuitable for desired uses. Pollutants may be biodegradable, non-biodegradable, or slowly degradable. Sewage, industrial chemicals, heavy metals from industrial processes, and household cleaners are examples of materials commonly discharged into streams and rivers. Additional water pollutants include chemicals, pesticides, fertilizers, motor oil, litter, and other components of polluted runoff. Water can also be polluted by pollutants that come from the air – a process called atmospheric deposition.

Freshwater and saltwater ecosystems are complex and interactive physical, chemical, and biological systems. Human activities cause changes in these attributes, and thus affect living resources over time. In this chapter, we will discuss some of the physical, chemical, and biological parameters of water that can be monitored by students in middle and high school. We will also introduce some of the excellent programs, such as GLOBE, which offer teachers extensive support, and students the opportunity to participate in national and international environmental science investigations.

PURE WATER IN NATURE?

Finding pure water – that is, water with no impurities – is very unlikely in nature. One of liquid water's unique properties is its ability to dissolve a wide variety of compounds. Water's superiority as a solvent plays a key role in carrying dissolved nutrients into the cells of living organisms, and removing cellular waste. But it also means that water is easily polluted by water-soluble materials.

HUMAN ACTIVITIES AND WATER POLLUTION

Human activities can modify water quality in two ways. First, water quality is changed when we add pollutants, including:

- sediment from erosion;
- nutrients from fertilizer and animal waste;
- heat from paved surfaces and industrial processes;
- fecal bacteria from sewage, farm animals, pets;
- industrial chemicals;
- heavy metals (includes lead, mercury, and cadmium from industrial sources, mining, and smelting);
- household cleaners;
- oil and gasoline;
- litter and debris;
- chemicals from the air; and
- pesticides.

The second way we impact water quality is by changing ecological processes that naturally purify water. Healthy aquatic ecosystems (wetlands, streams, bays, and oceans) all have natural processes that purify water of wastes. For example, microorganisms decompose organic wastes into nutrients that can be absorbed by plants. Wetlands act as natural filtering systems as they trap sediment, thereby preventing sediment from reaching streams. Wetlands also promote the decomposition of some toxic substances and waste. Healthy riparian (streamside) areas also help naturally purify water. As long as streams and rivers are not overloaded with wastes, they can use their natural recovery processes of dilution and bacterial decay. But slowly degradable and nondegradable pollutants, like mercury, PCBs, and some pesticides, cannot be eliminated by these natural processes. Mercury cannot ever be degraded, even over thousands of years. Virginia's Department of Health advises people to restrict or avoid eating fish from some rivers in Virginia due to mercury and PCB pollution. For a current list of these advisories, see *www.vdh.state.va.us/HHControl/fishing_advisories.htm.*

FACTORS RELATED TO WATER POLLUTION

There are many factors related to water pollution, including the number of people living in a watershed, how the land is used (agriculture, forested, urbanized, etc.), and the everyday behavior of the population. Many things we do every day can have an impact on water quality. Human activities, such as urbanization, dam construction, forestry practices, agricultural development, and road-building, have a profound effect on the quality of our water. When we fertilize our lawns, use pesticides, drive our cars, or use toxic chemicals we have the potential to add pollution to surface water and groundwater. Whether we make our living from mining, forestry, farming, or construction, we have the capacity to add nutrients, sediments, toxics, minerals, or acids to lakes and streams. Every land-use decision we make can either improve water quality, or diminish it.

Other pollutants enter water from **atmospheric deposition** – when pollutants in the air fall on the land or water. Nitrogen is one of the most common air deposition pollutants. In fact, according to the Alliance for the Chesapeake Bay, it is estimated that roughly a quarter of the nitrogen entering the Chesapeake Bay is from air sources. While there are some natural sources of emissions, most of these air-borne pollutants come from fossil fuel burning, industrial processes, cars and other forms of transportation, and fertilizer.

WATER POLLUTANTS, THEIR IMPACTS, AND APPROPRIATE TEST METHODS

Common water pollutants can be placed in a few categories or classes. This table shows some of these pollutants, and tests that middle or high school students can conduct. More details about several key pollutants follow the chart.

Chemical and Physical Water Pollutants			
Category	**Examples**	**Impacts on Water Quality**	**Test Methods for Middle or High School**
Thermal pollution	Paved surfaces and roofs become hot, and transfer heat to rainwater. Water also absorbs heat when it is used to cool industrial and power plants.	Warm water holds less dissolved oxygen (DO) than cold water, so heated water lowers the DO in water bodies. Can kill organisms that require high levels of DO. Can disrupt spawning. Causes increased respiration rates and oxygen consumption in aquatic organisms, and makes them more vulnerable to disease, parasites, and toxic chemicals.	• Thermometers • Computer or calculator probes • Macroinvertebrate populations as indicators • Test kits and probes are available that determine the concentrations of dissolved oxygen.
Sediment or suspended matter	Main source: soil eroded from the land. Insoluble particles of soil and other solids that become suspended in water.	Sediment can clog gills; settle out, destroying feeding and spawning grounds of aquatic animals; cloud water and reduce photosynthesis; carry pesticides, bacteria, and other harmful substances; and disrupt aquatic food webs.	• Transparency tube • Turbidity test kits • Macroinvertebrate populations as indicators

Chemical and Physical Water Pollutants Continued…			
Category	**Examples**	**Impacts on Water Quality**	**Test Methods for Middle or High School**
Plant nutrients (Water-soluble nitrates and phosphates)	*Human sources:* sewage treatment plants, fertilizer runoff, vehicle exhaust, atmospheric deposition, feedlot/farm manure, and eroded soil. *Natural sources:* soil, wild animal waste, decaying organic material, the atmosphere, and groundwater discharge. Pesticides.	1. Excessive growth of algae ("algae blooms" or "red tide") and other aquatic plants. Bacteria decompose the algae when it dies, and can deplete water of dissolved oxygen. Low DO can kill or stress aquatic animals. 2. Excessive levels of nitrate in drinking water lowers the oxygen-carrying capacity of the blood; this can cause miscarriages and cause "blue baby syndrome" in infants less than one year of age.	Chemical analysis test kits can determine the presence and concentrations of nitrate and phosphorus. Test kits and probes are available that determine the concentrations of dissolved oxygen.
Organic chemicals and water-soluble inorganic chemicals	Gasoline and oil. Cleaning solvents. Detergents. Compounds of toxic metals, including mercury and lead. Many other chemicals.	High levels of these chemicals can threaten human health and harm fish and other aquatic life.	K–12 students can do visual assessments, looking for oil spills, foam indicating detergents, and other visual clues. Macroinvertebrate populations serve as indicators of water quality.
Litter and debris	Intentional and accidental litter. Sources: fast food consumption, smoking-related litter, illegal dumping (tires, refrigerators, etc.), fishing and other activities.	Ingestion and entanglement of wildlife. Habitat destruction. Costs associated with cleanups. Economic impacts as people avoid visiting littered beaches, etc.	Students can survey the litter and debris they find at a local beach or riverside area. See the Helping Clean Up a Waterway and A Scientific Cleanup lesson plans in this packet.
Genetic Pollution	Nonnative species including plants (hydrilla, purple loosestrife, Eurasian water-milfoil) and animals (rapa whelks, mute swan, nutria).	Aquatic systems are disrupted by the deliberate or accidental introduction of nonnative species, as the nonnative species can crowd out native species, reduce biodiversity, and cause economic losses. The principal method of introduction into marine systems is through the intake and discharge of ballast from ships. Ballast water can contain microscopic organisms as well as the early life stages of larger plants and animals.	K–12 students can do visual assessments, looking for invasive nonnative plants and animals. See the Endangered Aquatic Species chapter for more information.

Can Your Class Monitor Water Quality?

Yes it can! A school-based water quality monitoring program can be as simple or as complicated as you would like. Start simply using easy-to-use field test kits, such as those you can purchase from LaMotte, Hach, or Chemetrics (see Equipment and Technology appendix for ordering information). See the lesson "Evaluating A Stream" for several ideas – from an activity that can be done quickly on your school grounds with just a thermometer, to more extensive monitoring activities.

Some schools monitor benthic macroinvertebrates on a quarterly basis, while others monitor standard physical-chemical parameters once a month using field equipment (including hand-held technology whenever available). A stream, pond, or other water body on your school grounds would make a convenient monitoring site, plus one that is relevant to the students. Water monitoring will teach students about the health of the water at your monitoring site, plus they can learn to use observation, hypothesizing, data collection, data analysis, and communication through graphical representation (graphs, charts, and diagrams).

Answers to Your Questions about Water Monitoring

Once you decide to start a water monitoring program in your school, you will find you have many questions. When should you monitor? How do you use the equipment? Luckily, all the answers you are looking for can be found through educational programs (including GLOBE) and through publications on the Internet. We've listed a few resources here but for a more complete list, see the Resources appendix, as well as the Water SOL and Other Curriculum Materials appendix.

The GLOBE Program

Web site: *www.globe.gov*

GLOBE is a worldwide hands-on, primary and secondary school-based education and science program. GLOBE provides assistance to teachers through training at professional development workshops, teacher's guides (available on the GLOBE web site), videos, and other materials.

A goal of GLOBE is to provide students an opportunity to learn by taking scientifically valid measurements in the fields of atmosphere, hydrology, soils, and land cover/phenology. Students can report their data through the Internet, create maps and graphs on the free interactive web site to analyze data sets, and collaborate with scientists and other GLOBE students around the world. See the GLOBE web site for a list of upcoming GLOBE workshops for teachers.

Center for Improved Engineering and Science Education

Web site: *www.ciese.org/currichome.html*

CIESE (located at Stevens Institute of Technology) sponsors and designs interdisciplinary projects that teachers can use to enhance their curriculum through use of the Internet. Each project supports the National Science Education Standards. Two of the CIESE projects, The Global Water Sampling Project and Take a Dip, have students compare

continued on next page

If you are interested in a sustained monitoring project, and sharing data with schools and scientists around the world, you can receive training from GLOBE, a worldwide hands-on, primary and secondary school-based education and science program. (See box on this page for more information.)

Key Indicators of Water Quality

Let's look at the key indicators of water quality. These are the parameters that you will most likely want to have your class monitor. For detailed step-by-step instructions on monitoring these parameters, consult the instructions that come with your test kits and

Answers to Your Questions about Water Monitoring Continued…

the water quality of their local river, stream, lake, or pond with other freshwater sources around the world. Step-by-step instructions for measuring temperature, pH, dissolved oxygen, nitrates, phosphates, macroinvertebrates, and other parameters are provided on their web site, as well as background information on the parameters.

GREEN (Global Rivers Environmental Education Network)

Web site: *www.green.org*

This program provides youth with educational opportunities to understand, improve, and sustain the water resources in their communities. The GREEN web site includes test procedures, sample data sheets, and many other teacher resources. Also, from their web site, you can order chemical (and biological) monitoring equipment, field test kits, and manuals for students and educators.

Healthy Water, Healthy People

Web site:www.healthywater.org

This water quality education program is sponsored by Project WET (www.projectwet.org) and the Hach Scientific Foundation. The program offers hands-on activity guides, testing kits, networking/training opportunities and extensive online resources. The activity guide features classroom lessons with test kit extensions that can be used to prepare students to conduct meaningful field investigations. Healthy Water, Healthy People materials can be ordered online by anyone interested in teaching about water quality.

U.S. EPA Manuals

Web site: *www.epa.gov/owow/monitoring/vol.html*

The U.S. Environmental Protection Agency has fact sheets about the process of starting a monitoring program, and several methods manuals that will walk you through the steps. Manuals have been developed for stream monitoring, as well as for estuaries, lakes, and wetlands. You can select the chapters that interest you, and print them from the EPA web site. These publications are packed with protocols, practical hints, and instructions for making some of your own equipment.

Virginia Department of Environmental Quality, Citizen Monitoring Program

Web site: *www.deq.state.va.us/cmonitor*

Virginia actively encourages citizens to monitor water quality, and has many resources that will assist you in getting started. Many answers on how to monitor can be found in the Virginia Citizen Monitoring Methods Manual, located at the above web site.

analyzing instruments. Also, many resources can be found on the Internet that will provide more in-depth information on these parameters. See the box Answers to Your Questions about Water Monitoring for web addresses.

Water Temperature

Water temperature has a large influence on the organisms living in the water, as it influences biological activity and chemical processes. For example, water temperature influences the rate of plant photosynthesis, the timing of reproduction and migration, and the metabolic rates of aquatic organisms. Also, as the temperature of water increases, the capacity of water to hold dissolved oxygen (DO) becomes lower. Colder water will have a higher DO level than warmer water.

Runoff from paved roads, parking lots, rooftops, and other similar impervious surfaces can increase water temperature, and reduce the diversity of aquatic life.

Measuring temperature: Thermometers or probes can be used by students to measure water temperature.

pH

pH is a measure of how acidic or basic (alkaline) a solution is. The pH of water is critical to the survival of most aquatic plants and animals. For example, if water becomes too acidic, the eggs of some species of frogs will not develop. Most organisms are highly susceptible to changes in the pH of their surroundings or water supply, so fluctuations in pH or long-term acidification of a water body are exceedingly harmful. The pH of water can affect the pH of an organism's body fluids, can affect the speed of chemical reactions within the body, and can impact biological activities including photosynthesis, respiration, and reproduction. For example, the colorful brook trout, found in many of Virginia's streams, will experience inhibited reproduction if the pH falls below 5, and adult brook trout will die when the pH is below 4.5.

Some of the factors that determine the pH of water are bacterial activity, photosynthesis and respiration, water turbulence, human-made wastes, acid precipitation, chemicals found in runoff, and accidental spills. Normal pH in most of Virginia's surface waters is 6.0 to 8.0, although some swamps in Virginia are naturally lower. In Virginia's mountains, many streams have low natural buffering capacity, and have been affected by acid rain. Acid precipitation in Virginia has been measured at 4.5 and lower (National Atmospheric Deposition Program (*http://nadp.sws.uiuc.edu*). This acidic precipitation has negative impacts on aquatic ecosystems, mostly in Virginia's mountainous areas due to low acid neutralization capacity associated with the bedrock type, thin soil cover, and topography.

Measuring pH: Several easy-to-use probes and test kits are available for testing the pH of water. Note: Test paper strips to obtain pH are not suitable for use in salt water, as they will not provide consistent measurements. Schools in the coastal plain should use probes or test kits.

Transparency

Even unpolluted water can have suspended particles, such as soil particles, tiny floating organisms, or fragments of dead plants. Natural runoff, wave action, and turbulent water can cause short periods of turbid, or unclear, water. Short-term turbidity, however, doesn't have the negative impacts that are associated with long-term turbidity. Human activities, including runoff from construction sites, urban areas, and agricultural fields, can contribute to high turbidity that can lasts for long periods. Heavy boat traffic and recreational personal watercraft can also stir up sediment and increase erosion from riverbanks. High levels of turbidity over long periods of time can greatly diminish the health and productivity of aquatic ecosystems. Suspended particles can clog gills of fish and other aquatic animals. Many animals living in water feed by filtering the water, and their filter-feeding system can become impaired when suspended material is in the water in large quantities. Turbid water also reduces photosynthesis in submerged aquatic plants, as light cannot penetrate as far into the water. When the suspended particles settle out, they can cover the feeding and spawning grounds of aquatic animals, thereby destroying critical habitat.

Measuring the transparency of water: Secchi disks (a weighted black and white patterned disks on a measured rope) are widely used to measure the transparency of deep water. Students should lower a Secchi disk into the water on the shady side of a boat or dock, and record the depth at which it just disappears from view. For shallow water, as found in a stream, use a transparency tube to measure the water's transparency. (Note: Transparency tubes are sometimes referred to as turbidity tubes.) Both of these are easy to use, inexpensive to purchase or make, and consistently accurate. Instructions for making Secchi disks and turbidity tubes can be found in the GLOBE hydrology protocols. Turbidity can also be measured with a turbidity field kit, or turbidity meter.

Nutrients

Nutrients, like nitrogen and phosphorus, that occur naturally in water, soil, and air, are essential to aquatic plants and animals, just as they are to agricultural crops, garden plants, and terrestrial animals. For example, nitrogen is used to synthesize protein in plants and animals, and phosphorus is critical in the process of photosynthesis. Both are essential to cellular growth and reproduction. In addition to natural sources, human activities contribute nutrients to the Chesapeake Bay and other water bodies. Human sources include point and nonpoint source discharges including effluent from wastewater treatment plants, urban stormwater runoff, lawn and agricultural fertilizer runoff, industrial discharges, livestock wastes, and failing septic systems. Another important source is atmospheric deposition from burning fossil fuels.

Excessive concentrations of nutrients can cause great harm to the water quality of our rivers, lakes, and the Chesapeake Bay.

Depending on their chemical forms, nitrogen and phosphorus can have significant direct or indirect impacts on plant growth, water clarity, sedimentation rates, and dissolved oxygen concentrations. As Virginia's population has grown, and land use in Virginia has changed from forests and wetlands to farms, urban areas, and suburbs, we have seen a tremendous increase in the amount of nutrients in our surface waters, including the Chesapeake Bay. In fact, the main cause of the Bay's poor water quality and aquatic habitat loss is elevated levels of nutrients.

According to the Chesapeake Bay Program,

> "Excess amounts of phosphorus and nitrogen cause rapid growth of phytoplankton, creating dense populations, or blooms. These blooms become so dense that they reduce the amount of sunlight available to submerged aquatic vegetation (SAV). Without sufficient light, plants cannot photosynthesize and produce the food they need to survive. The loss of sunlight can kill the grasses. Algae may also grow directly on the surface of SAV. Unconsumed algae will ultimately sink and be decomposed by bacteria in a process that depletes bottom waters of oxygen. Like humans, most aquatic species require oxygen. When oxygen in deep water is depleted, fish and other species will die unless they move to other areas of suitable habitat."

Measuring nutrients in water: Field test kits can be used to measure the concentrations of nitrates and phosphorus in a water body. Most kits rely on a color comparison in which the student matches the color of a prepared water sample to a set of provided standards.

Unpolluted water normally has less than 1 part per million (ppm) of nitrate and less than 0.03 ppm of phosphorus. The drinking water standard for nitrate nitrogen is 10 ppm. Nitrates in large amounts can cause "blue baby syndrome" (methemoglobinemia) in infants. See the Nitrates in Well Water lesson for more details.

NUTRIENT CONTROL STRATEGIES

Here are some of the strategies to decrease the amount of nutrients entering our streams, rivers and bays:

Phosphate Detergent Bans
Virginia instituted a ban on phosphate detergent in 1988, joining other states in the Chesapeake Bay watershed that took similar steps to decrease the amount of phosphorus entering the Bay.

Upgrades to Wastewater Treatment Plants
Driven by the Federal Water Pollution Control Act of 1972 (also known as the Clean Water Act) and the Water Quality Act of 1987, state and local governments have increasingly built and upgraded wastewater treatment plants to decrease this source of nutrients into streams. They are also investigating more effective technologies to increase nutrient removal.

The Implementation of Best Management Practices
Best management practices (BMPs) are techniques of working the land that minimize the impacts of disturbance and thus conserve soil and water resources. BMPs are designed to minimize surface runoff of nutrients and suspended material reaching streams from sources such as highways, construction sites, farms, and urban areas.

Dissolved Oxygen

Dissolved oxygen (DO) is important to the health of aquatic ecosystems, as all aquatic animals need oxygen for respiration. It is one of the best indicators of the water's health. Water bodies with high levels of DO are most likely healthy, and are capable of supporting a diversity of organisms. Oxygen enters water through aquatic plant photosynthesis and from the atmosphere. A riffle in a stream, where the water flows over rocks with turbulence, will boost the amount of oxygen in the water by putting more water in contact with the atmosphere. Currents and wind-generated waves will also increase the DO.

DO levels can be decreased by thermal pollution, and some pollutants like high levels of bacteria from sewage, or the rotting of plants. Oxygen is needed to aid in decomposition of organic matter. This is why an algae bloom, caused by excessive nutrients, can lead to decreased DO. Decomposition of large quantities of organic matter by bacteria can severely deplete the water of oxygen and make it uninhabitable for many species.

Removing streamside trees that shade the water will also cause the water to increase in temperature, and therefore will decrease the amount of DO the water can hold.

In addition to measuring DO, another important measurement is "DO percent saturation." Cold water can hold more DO than heated water. For example, freshwater at 8°C can hold up to 12 parts per million (ppm) of oxygen before it is 100% saturated. At 28°C, freshwater can hold only 8 ppm of DO before it is 100% saturated. Salinity of water will also affect DO levels, as freshwater can hold more DO than saltwater.

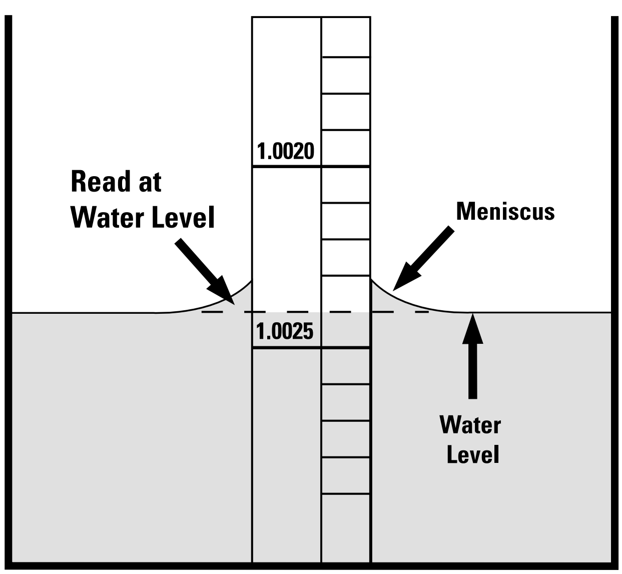
Measuring dissolved oxygen: Dissolved oxygen field test kits that measure DO to the nearest two tenths of a part per million (ppm) cost $30 to $90, and rely on the Winkler titration method. These tests usually involve more steps than the test kits for pH and nutrients, and have five chemicals that are added to the water sample in a prescribed order. Simplified test kits that measure DO at 0, 4 and 8 ppm also exist for younger children. DO meters or probes are expensive and need careful maintenance. For these reasons, most water monitoring programs use the field test kits. If you wish to measure DO percent saturation, a thermometer or temperature probe will also be needed.

Salinity

Schools near the Atlantic Ocean, the Chesapeake Bay, or tidal streams should

consider adding salinity (the amount of dissolved salts in water) to their school's water monitoring program. Salinity measurements can be used to track the impacts of storm water runoff as well as the impact of drought. Salinity levels control, to a large degree, the types of plants and animals that can live in the water. Some species tolerate only fresh water (salinity of 1.0 part per thousand or less), others tolerate only brackish water (intermediate levels of salinity), while others are adapted to live only in seawater where salinity levels are 30.0 ppt. To learn more about salinity and its importance in an estuary such as the Chesapeake Bay, see chapter 14 of the EPA's Volunteer Estuary Monitoring: A Methods Manual, available on-line at *www.epa.gov/owow/estuaries/monitor*.

Measuring salinity: Salinity can be measured either by physical methods (conductivity, density or refractivity), or by chemical methods (measuring the chloride concentration with a field test kit). The GLOBE program recommends the use of hydrometers to measure the density of water. The density of water is related to the amount of salt dissolved in it, and a hydrometer measures this density, or specific gravity. Using the reading on the hydrometer along with the temperature of the water, students will use a chart to determine the water's salinity. Full instructions can be found on the GLOBE web site, in the EPA's Volunteer Estuary Monitoring: A Methods Manual, or from the hydrometer's manufacturer.



How to read a hydrometer

Monitoring Living Organisms

Biological assessments are evaluations of the condition of water bodies using surveys and other direct measurements of resident biological organisms (macroinvertebrates, fish, and plants). Biological assessment results are used to answer the question of whether water bodies support survival and reproduction of desirable fish, shellfish, and other aquatic species.

Key living ecological indicators of water quality that middle school or high school students can help monitor include benthic macroinvertebrates, submerged aquatic vegetation, and streamside forests (riparian buffers).

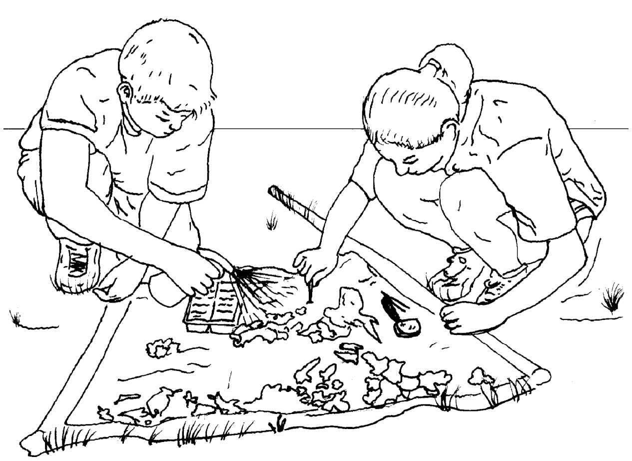
Benthic Macroinvertebrates

Benthic macroinvertebrates are bottom dwelling organisms that live in, crawl upon, or attach themselves to the bottom (or substrate) of a water body. They include the larvae of many insect species, including dragonflies, damselflies, mayflies, stoneflies, water beetles, and true bugs. Other macroinvertebrates include crustaceans (i.e., crayfish, shrimp, sow bugs and sideswimmers) and non-arthropods (i.e., flatworms, aquatic earthworms, snails, mussels, and clams).

Students can learn many things by looking at the macroinvertebrates living in a stream. According to the Virginia Save Our Streams (SOS) program:

> "Because many macroinvertebrates live in the stream year-round and sometimes over multiple years, their presence or absence provides valuable information about a river's health over time."

Virginia SOS leads the way in teaching about water quality monitoring by using aquatic invertebrates as indicators. Volunteers who have been trained in the SOS method collect the insect larvae and other "critters" that live in a stream, then determine the quality of the water based on the animals that live there.



SOS' goal is to ensure that future generations inherit restored and protected streams, rivers, and estuaries across Virginia. While training volunteers to conduct water quality monitoring is their priority activity, they also work with schools and teachers.

Monitoring macroinvertebrates: The methods for collecting and identifying macroinvertebrates can be learned at a workshop offered by the Virginia SOS program. See their web site (*www.sosva.com*) for information or call 540-377-6179. As an alternative, teachers can learn if there is a group in the area that has trained monitors willing to assist your class with identification of these aquatic animals. The Virginia SOS web site has instructions on how to collect and identify macroinvertebrates, plus downloadable data sheets and "Bug ID cards". In addition, this site has information on habitat assessment, tips on where to monitor, and information on how to schedule a training or demonstration session.

Submerged Aquatic Vegetation

In the shallow water of the Chesapeake Bay and its tributaries, where sunlight penetrates the water to the bottom, aquatic plants often grow. Known as submerged aquatic vegetation (SAV) or seagrasses, these plants are rooted vascular plants that grow up to the water surface but not above it (although a few species have flowers or tufts that may stick a few centimeters above the surface).

According to the U.S. EPA (Volunteer Estuary Monitoring: A Methods Manual):

"The plants are important components of estuarine systems, providing shelter, habitat, and a food source for many organisms. They also benefit estuarine species indirectly by helping to maintain the viability of the ecosystem. Their photosynthesis adds dissolved oxygen to the water, and their leaves and roots help stabilize the shoreline against erosion. The plants also absorb nutrients, which can be major estuarine pollutants."

Like terrestrial habitats, beds of SAV have been diminished over the years due to human activities. By monitoring the occurrence of SAV beds and the changes in their distribution, density, and species composition, students can help determine the health and status of SAV.

The Chesapeake 2000 agreement has a goal to protect and restore more than 110,000 acres of SAV beds in the Bay. To learn more about SAV, refer to the Virginia Institute of Marine Sciences (*www.vims.edu/bio/sav/aboutsav.html*). The Chesapeake Bay Foundation (*www.cbf.org*) has a "Guide to Underwater Grasses" and a program called SAVing SAV that helps schools plant tidal or non-tidal wetlands. The Alliance for the Chesapeake Bay also has SAV monitoring and restoration programs.

Funding Your Water Monitoring Project

Funding sources are listed in the Grant and Other Support appendix. As you create your budget, be sure to include money for:

- Monitoring equipment such as test kits, Secchi disks, water samplers, thermometers, and a bin to keep all equipment in.
- Chemicals (reagents) for test kits. (Most test kits come with enough chemicals to conduct 30 or 50 tests. After those chemicals are used, you will need to purchase replacement chemicals, but not replace the entire test kit.)
- Funds for teacher workshops as some organizations charge a fee to cover the expenses associated with a workshop.
- Travel associated with teacher workshops and class field trips.

Streamside Plants (Riparian Forests or Buffers)

Streamside forests and wetlands are vital habitats, supporting living resource abundance by providing key food and habitat for a variety of species. They also protect water quality by naturally processing pollutants before they enter the water. Students can observe the habitat found along streams in your area using a habitat field sheet, as found on the Virginia SOS web site (*www.sosva.com*). The lessons Restoring a Stream and Observing a Stream also have information on the benefits of riparian buffers.

Other living indicators

Many animal and plant species play significant roles in the water quality of Virginia's rivers and the Chesapeake Bay. Programs have been created that help students and interested citizens monitor different plant and animal communities. In addition to monitoring macroinvertebrates and SAV, you can monitor birds or amphibians (salamanders and frogs). The National Zoo offers teacher workshops, often in Winchester, Virginia. Past workshops have included Amphibian Monitoring Methods, Bird Identification and Monitoring Techniques, and Forest Biodiversity Monitoring. For upcoming workshops, see their web site: *www.nationalzoo.si.edu/Education/Teacher Workshops.*

The Virginia Department of Game and Inland Fisheries (DGIF) also offers *WildlifeMapping* – an outreach program that allows school children, citizens, community groups, and other organizations to collect wildlife-related information that will be available to everyone. The program provides an opportunity for students and volunteers to perform field studies that contribute to the state's biological databases. Learn more at the DGIF web site: *www.dgif.state.va.us/wildlifemapping* or Virginia Tech's Institute for Connecting Science Research to the Classroom *www.icsrc.org/TILT/Wildlife/wildlife.html*

Monitoring the water quality of your nearby stream, river, lake, or bay can be simple or complex, as your time and budget allow. But even the simplest exercise in monitoring water quality will teach your students a great deal about our water resources, how they are dynamic yet fragile, and how they need our stewardship.

Water Monitoring Equipment

Vendors of field test kits, probes, meters, water samplers, and other water quality monitoring equipment are listed in the Equipment and Technology appendix. It is also possible to make some equipment yourself if budgets are tight. For example, Secchi disks (used to measure water transparency) can be made inexpensively. See the GLOBE hydrology protocols (*www.globe.gov*) or Chapter 15 of the U.S. EPA Volunteer Estuary Monitoring: A Methods Manual for details: *www.epa.gov/owow/estuaries/monitor*.

Resources

For the teacher...

Alliance for the Chesapeake Bay. *www.acb-online.org*

Center for Improved Engineering and Science Education (CIESE). *www.ciese.org/currichome.html*

Chesapeake Bay Foundation. *www.cbf.org*

GLOBE. *www.globe.gov*

GREEN (Global Rivers Environmental Education Network). *www.green.org*

Healthy Water, Healthy People. *www.healthywater.org*

How Healthy is Our Water? *www.knowledge.state.va.us/cgi-bin/lesview.cgi?idl=855*

National Atmospheric Deposition Program. *http://nadp.sws.uiuc.edu*

The National Zoo offers teacher workshops, often in Winchester, Virginia. Past workshops have included Amphibian Monitoring Methods, Bird Identification and Monitoring Techniques, and Forest Biodiversity Monitoring. *www.nationalzoo.si.edu/Education/Teacher Workshops*

U.S. Environmental Protection Agency's Manuals for water monitoring:

Volunteer Stream Monitoring: A Methods Manual. www.epa.gov/owow/monitoring/volunteer/stream

Volunteer Estuary Monitoring: A Methods Manual. www.epa.gov/owow/estuaries/monitor

Volunteer Lake Monitoring: A Methods Manual. www.epa.gov/owow/monitoring/lakevm.html

Volunteer Wetlands Monitoring: A Methods Manual. www.epa.gov/owow/wetlands/monitor/volmonitor.html

U.S. Geological Survey web site about Monitoring Nutrients in the Major Rivers Draining to Chesapeake *Bay. http://va.water.usgs.gov/online_pubs/WRIR/99-4238/99-4238.html*

Virginia Department of Conservation and Recreation

Simple things we can all do to protect our water resources. *www.dcr.state.va.us/sw/varivers.htm*

Virginia Department of Environmental Quality, Citizen Monitoring Program. *www.deq.state.va.us/cmonitor*

Virginia Department of Health: Fishing Advisories. *www.vdh.state.va.us/HHControl/fishing_advisories.htm*

Virginia Institute of Marine Sciences: Submerged Aquatic Vegetation (SAV). *www.vims.edu/bio/sav/aboutsav.html*

Virginia Institute for Marine Sciences – Ocean Sciences Teacher Resource Center. *www.vims.edu/bridge*

The Volunteer Monitor: The National Newsletter of Volunteer Water Quality Monitoring.

This newsletter, available on-line, facilitates the exchange of ideas, monitoring methods, and practical advice among volunteer environmental monitoring groups across the nation. The Spring 1993 issue (*www.epa.gov/volunteer/spring93/index.html*) is devoted to school-based programs and contains an excellent collection of articles written by teachers. *www.epa.gov/owow/monitoring/volunteer/vm_index.html*

For the student...

Water Quality Report for Kids (What's Up with our Nation's Waters?

Booklet, designed primarily for middle-school-aged youth, presents key findings of the EPA's National Water Quality Report and includes projects for school or fun, a glossary, and resources for more information. *www.epa.gov/owow/monitoring/reporting.html*