COOPERATIVE EXTENSION SERVICE • UNIVERSITY OF KENTUCKY COLLEGE OF AGRICULTURE, LEXINGTON, KY, 40546

4DE-02po

Unit 2: What is Water Quality?

The Southern Region 4-H_2O Ambassador Program

Educating a new generation of water resource protectors and conservators

Applying knowledge to improve water quality
Southern Regional Water Program
A Partnership of USDA NIFA & Land Grant Colleges and Universities

Agriculture and Natural Resources • Family and Consumer Sciences • 4-H Youth Development • Community and Economic Development

Introduction

The Southern Region 4-H2O Ambassador Program addresses key concepts related to watershed education. The program is part of an ongoing effort within the Southern Region to educate and empower youth to conserve and protect our water resources.

A Southern Region 4-H2O Ambassador is a 4-Her, 8 to 14 years of age, who has successfully completed units 1 through 3 and has been acknowledged by the Southern Region Water Program as having the skills and knowledge to successfully complete a community-based service project. At the completion of the community-based service project, each 4-H_2O Ambassador will be recognized on a local, statewide, and multi-state (regional) basis.

Each unit includes:

Skimming the Surface	Background information to help instructors prepare for activities
Wading In	Hands-on activities
4-H_2Opportunities	Extensions to particular activities (not required to become an ambassador)
Diving Deeper	Additional activities (not required to become an ambassador)
Sink or Swim	Evaluation options

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UNIT 2
What is Water Quality?

Overview
In this unit, 4-Hers will learn different methods for assessing water quality.

4-H_2Objectives
Upon completion of this unit youth will be able to:
- Define water quality.
- List different methods of assessing water quality.
- Take water quality measurements using various instruments and methods.
- Assess quality of local water body using chemical, biological, and physical measurements/observations.

Focus Questions
- What is water quality?
- Why is water quality important?
- How is water quality measured?

4-H Life Skills
- **Head:** Learning to Learn, Critical Thinking, and Keeping Records
- **Heart:** Communication, Cooperation, and Sharing
- **Hands:** Leadership, Responsible Citizenship, Contributions to a Group Effort, and Teamwork
- **Health:** Self-Responsibility

National Education Standards

Topic	Section	Grade level
1. The Nature of Science	A. The Scientific World View	3-5
	B. Scientific Inquiry	3-5
	C. The Scientific Enterprise	3-8
3. The Nature of Technology	A. Technology and Science	3-8
4. The Physical Setting	B. The Earth	6-8
	C. Processes the Shape the Earth	6-8
5. The Living Environment	A. Diversity of Life	3-5
	D. Interdependence of Life	6-8
	F. Evolution of Life	6-8
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11. Common Themes	A. Systems	3-8
	C. Constancy and Change	6-8
12. Habits of Mind	A. Values and Attitudes	3-8

Skimming the Surface

Water Quality
Water quality describes the chemical, physical and biological condition of a body of water. National and state agencies charged with monitoring and protecting water quality establish standards for each of these three classes of attributes. In the United States, all public water supplies must be measured against these standards, which are developed by the federal government's Environmental Protection Agency (EPA).

Water quality standards are designed to protect the designated beneficial uses of a water body. Examples of beneficial uses include support of aquatic life, fish consumption, shellfish harvesting, drinking, primary contact (swimming), and secondary contact (boating). The standards are used to determine permits for industrial or other discharges and to regulate any other activities that control water quality. The federal EPA requires that water quality standards be reviewed and revised every three years. The establishment of new standards requires public participation.

Water quality standards consist of statements that describe water quality requirements and include at least the following three components:
- Designated uses are specified for each water body (or segment of stream or river). These uses can be related to water supply, aquatic life, agriculture, or recreation.
- Water quality criteria include general statements that describe good water quality and specific numerical concentrations for various parameters. Water quality criteria are adjusted as needed to reflect changes in law and science.
- Antidegradation policy is designed to maintain and protect the existing water uses for each water body.

To determine the water quality, the chemical, biological and physical conditions of a water body must be measured. Chemical measurements, biological surveys, and visual observations provide a "big picture" of what's happening in a water body.

Chemical
In this unit, youth will learn about bacteria, dissolved oxygen, electrical conductivity, nitrate, pH, phosphate, and temperature. For background information on each of these parameters see the **Dive-In! parameter testing sheets** in this unit.

Biological

Ecosystems are composed of interrelated elements. Major components of most systems are water, land (rock and soils), air, and living things (plants and animals including humans). The components of an ecosystem are related so that when one is disturbed or altered, the other components may also be affected.

Aquatic ecosystems are water bodies containing living organisms and non-living elements all related to each other. The air and land that surround the body of water are also part of the ecosystem. Therefore, the components in the system not only interact with each other and the water but are affected by what happens to the air and land connected to them. The system constantly attempts to achieve and maintain a balance between its components. All the bodies of water that we know are aquatic ecosystems. Oceans, marshes, ponds, lakes, and streams are just a few examples. These aquatic ecosystems support life at many levels. They support microorganisms, phytoplankton and zooplankton on the small end of the scale and large mammals and sharks as examples of the other end of the scale. The health of these organisms reflects the health of the aquatic system they live in.

The presence, condition, and numbers of certain types of fish, insects, algae, and plants can be used as indicators of the health of a body of water. Scientists have developed indices based on these biological indicators.

Many living spaces can be identified within an aquatic ecosystem. Living organisms in a water body are adapted for the environmental conditions where they live (Table 1).

Table 1. Areas or zones in a lake.

Water body area	Characteristics	Life forms
Pelagic zone (open water)	Turbulent or flowing water	Phytoplankton (algae), zooplankton, fish
Benthic zone (bottom sediments)	Mud or sand, decaying organic matter; may have dim light or low oxygen	Invertebrates (worms, insects)
Littoral zone (shore or bank area)	Transition area between shore and land, shallow water; may have plant growth	Aquatic plants, algae, zooplankton, insects

Physical

In this unit youth will learn about physical characteristics of a water body. Youth will make observations related to the movement of the water (e.g., fast, slow, still), tree canopy (e.g., full shade, part shade, exposed), bottom composition (e.g., bedrock, boulder, cobble, gravel, sand, silt), land use, water appearance, water odor, and presence and size of vegetation.

Wading In

Perusing the Parameters

Time: Part 1–2 hours / Part 2–2 hours (depending on sampling locations)

This activity is used to learn about different water quality parameters. Parameters may include: alkalinity, hardness, total dissolved solids, pH, dissolved oxygen, conductivity, turbidity, nitrate, phosphate, bacteria, temperature, and aquatic insects (macroinvertebrates).

4-H_2Objectives

- Identify different chemical and biological parameters used for testing water.
- Understand how to measure for different chemical and biological water parameters.
- Understand the meaning of results collected from chemical and biological water parameters.

Materials

- Art supplies, such as poster board, markers, pipe cleaners, sculpting clay, etc., for presentations, and dress-up items, such as goggles, for skits
- Water testing equipment, such as PRIDE Clean Stream Kit, Lamotte and/or Hach testing equipment
- Tap water and paper cups to put tap water in for testing
- Access to water body, such as stream, pond, or lake (preferably a stream for aquatic macroinvertebrate sampling)
- Pens/pencils and paper for recording results
- Dive-In! testing sheets in this guide

For additional information the *Healthy Water, Healthy People (HWHP) Testing Kit Manual* is recommended. For more information visit: www.healthywater.org.

Remember safety rules when testing near a water body. An adult should always be present. Life jackets may or may not be needed depending on each individual situation. Please use your best judgment.

CAUTION: Follow all safety precautions for chemical tests. Some tests require gloves and safety goggles.

Consider printing out and laminating **Dive-In! testing sheets** so they can be reused and will be protected from water.

Instructions

Part 1

1. Divide participants into groups of four or five and assign each group one parameter to study. Hand out Dive-In! testing sheets and/or HWHP Testing Kits Manuals.
2. Each group should receive the necessary water testing equipment to measure their parameter in water. They will be required to learn how to use the equipment to measure their parameter and also they will need to know what the data they collect means. For example, if a group measures a pH of 5 they will need to know that the water they measured is acidic.
3. Have groups practice measuring their parameter in the classroom. (If necessary use water from tap or water brought in from local water body.)
4. Challenge each group to find a creative way to teach the other groups about their parameter. Tell groups to focus on what the parameter is, why it is important, and how to measure for it. They must present this information in a way that will ensure that the entire group will never forget that parameter and also what it measures. Each group will be given a maximum of five minutes to present their findings to the rest of the participants. Ideas to present information: skit, song, rap, poem, poster, mime, etc.
5. Have each group present their findings to the entire group.

Part 2

6. Have all participants come back together. Now divide participants into new water sampling groups, with one participant from each parameter group in each new water sampling group. That participant will be considered the "expert" of the parameter he/she learned in their previous groups and will assist the others in his/her water sampling group when testing for this parameter. Example: The group of students that learned about pH will each go to a different new group so that each new water sampling group will have one expert in pH.
7. Complete **H_2O to Go!** and **Catch and Release!** activities utilizing new groups. Have new groups measure all parameters in the field (at a local water body, preferably a stream for aquatic macroinvertebrate sampling).
8. Have everyone come back together and discuss data collected.

Reflection Questions

- Why is it important to learn about the water quality of local stream, rivers, lakes, and ponds?
- How can we improve the water quality of our local water bodies?

4-H Life Skills

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Dive-In! Aquatic Macroinvertebrates

An invertebrate is an animal that lacks an internal skeleton of cartilage or bone. "Macro" refers to the size of the invertebrate. Although very small, these invertebrates are large enough to be seen without a microscope. Thus "aquatic macroinvertebrates" are invertebrates that are large enough to see with the naked eye and that live in aquatic environments. The presence and identification of aquatic macroinvertebrates can help us learn about the water quality of rivers, streams, lakes and other aquatic ecosystems.

Aquatic macroinvertebrates are benthic, meaning they are generally found on the bottom of a stream, lake, or other water body. In most instances, macroinvertebrates stay in the same area and do not move over large distances. So if a pollutant enters a water body, macroinvertebrates cannot easily move away from that pollutant. Different species of macroinvertebrates react differently to pollution and other environmental stressors, such as habitat change. Some macroinvertebrates are tolerant to pollution and can live in water bodies that are unhealthy and polluted; however, other macroinvertebrates need very clean, healthy water to live and survive and are very intolerant to pollution.

Collecting and identifying the different types of macroinvertebrates present in a water body can help us understand about that water body and tell us whether the water is healthy or not. For example, a stream quality assessment form can be used to determine the quality (poor, fair, good, or excellent) of a section of a stream based on the diversity of macroinvertebrates present.

Aquatic biologists have developed a variety of keys and references to identify macroinvertebrates. These illustrated keys contain the information needed to identify and classify freshwater invertebrates. One such key is the *Key to Macroinvertebrate Life in the River* developed by the University of Wisconsin–Extension. This key can be downloaded and printed at http://watermonitoring.uwex.edu/pdf/level1/riverkey.pdf (Figure 1). An internet search for "key to macroinvertebrate life" will yield numerous resources.

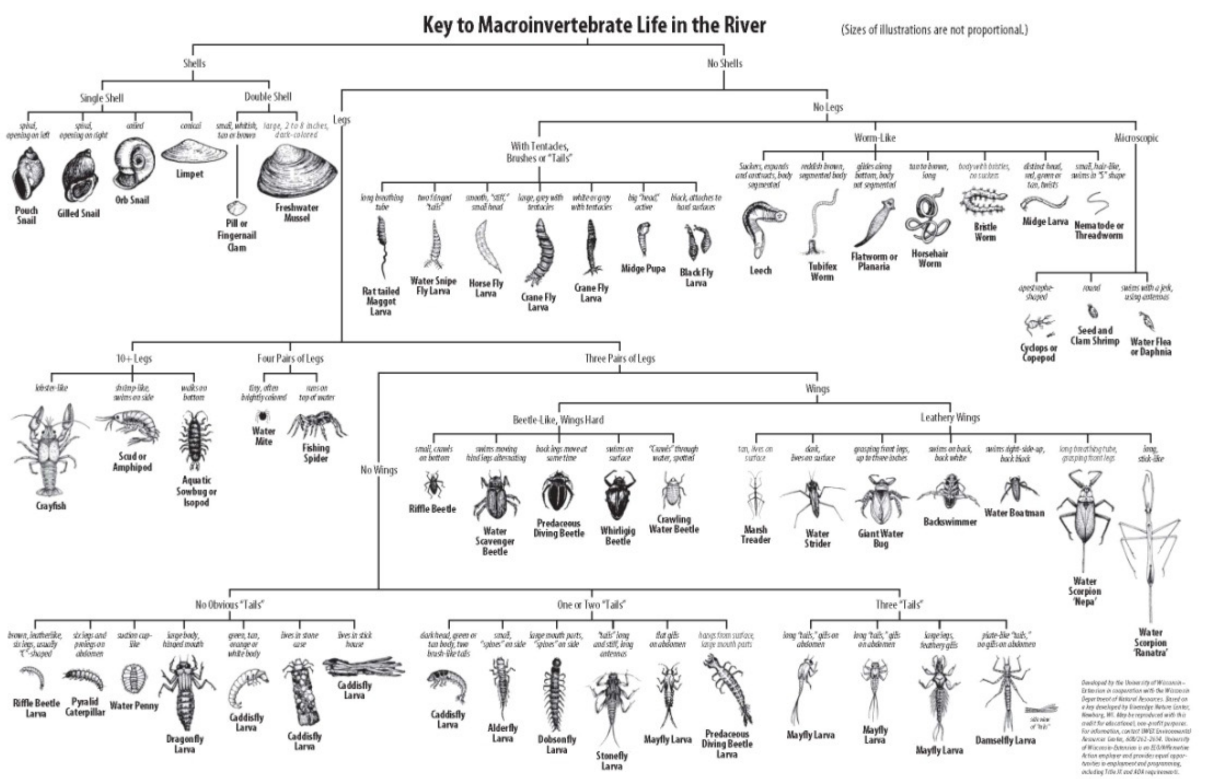
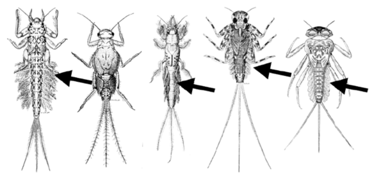
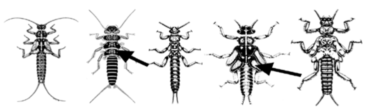
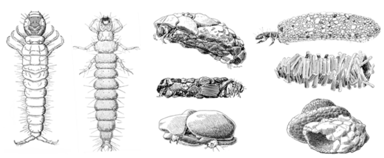
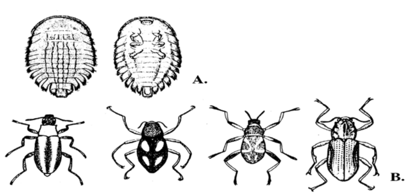
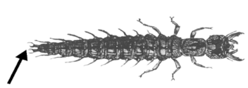
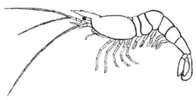
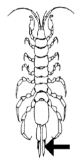
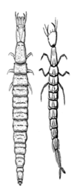
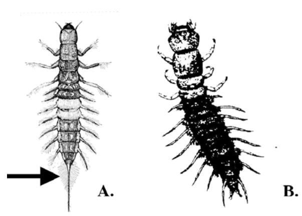
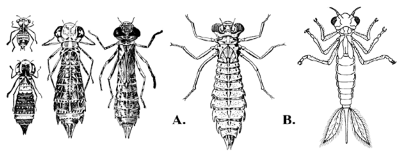
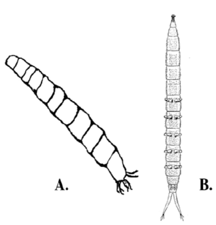
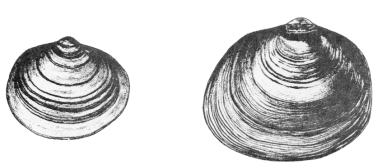


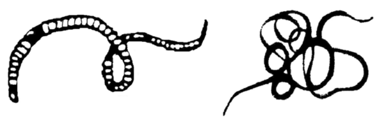
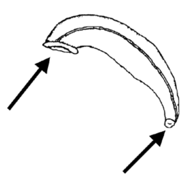
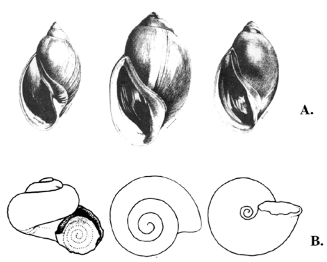
Figure 1. A key to identifying macroinvertebrates.

Source: Developed by the University of Wisconsin–Extension in cooperation with the Wisconsin Department of Natural Resources.

For information on collecting and identifying macroinvertebrates see the Catch and Release! activity in this unit.

Group 1. Pollution sensitive organisms found in good quality water.	
	The order Ephemeroptera contains the mayflies. The most distinguishing characteristics of this order are where the gills are located, along the abdomen (see arrows); the gills can look like feathers or leaves. Their body length ranges from 3 to 33mm. They can also be identified by their three “tails” located at the end of their abdomen (sometimes, however, they can have only two).
	The order Plecoptera contains the stoneflies. The most distinguishing characteristics of this order are where the gills are located, along the thorax (see arrows); the gills can look like feathers or leaves. Their body length ranges from 4 to 30mm. They can also be identified by their two “tails” located at the end of their abdomen. To distinguish Plecoptera from Ephemeroptera, remember that Plecoptera have their gills in their “armpits” while Ephemeroptera have their gills on their abdomen.
	The order Trichoptera contains the caddisflies. They resemble grubs or caterpillars, with body lengths ranging from 3 to 45mm. Many species make cases out of woody debris, sand, or even small rocks which they fasten together with silk which they produce. They can also use silk to make a pupal case or to modify their existing case during metamorphosis. Immature Lepidoptera (butterflies and moths) also produce silk; in fact, Lepidoptera is closely related to Trichoptera.
	The order Coleoptera contains the water pennies and the riffle beetles. Water pennies (A.) have a flat, saucer shaped body with a fringe of short, fine hair around the edge. Their body length ranges from 3-10mm.Their legs are located on their underside and cannot be seen from the top. They are found clinging to stones and are hard to dislodge using only a kick net. Look on the rocks in your area for water pennies. Riffle beetles (B.) look like beetles you find in your yard. Their body length ranges from 1-8mm, they have three pair of legs, two pair of wings (the first of which has evolved into a hard covering called the elytra which protects the second pair), and variable mouthparts. The elytra comes together and forms a line down the middle of the back.
	The order Megaloptera contains the dobsonflies or hellgrammites. They can be quite large (25-90mm) with robust, toothed jaws. They have a pair of stout, yet flexible filaments the project from almost each segment of the abdomen. Under each of these projections, the gill “tufts” can be seen (they look like little bits of cotton balls). At the end of the abdomen are 2 fleshy appendages with 2 claws at the end of each one (see arrow).
	Gilled snails with shells that open on the right finish the last of group 1.

Group 2. Somewhat pollution tolerant organisms that can be found in good or fair quality water.	
	The order Decapoda contains the crayfish or crawdads, which resemble small lobsters. Their body length ranges from 10-150mm. Be careful of their claws as they can pinch pretty hard.
	The order Isopoda contains the sowbugs. Their body length ranges from 5-20mm. Their bodies are flattened from top to bottom and they are dark gray in color with occasional mottling of black or brown. They have 2 pair of antennae, one being longer than the other and they have 7 pair of walking legs, with the first pair having a hinged claw. They also have 2 flat, fork-like structures that stick out at the end of the abdomen (see arrow).
	The order Amphipoda contains the scuds or sideswimmers. Their body length ranges from 5-20mm and is flattened from side to side. They are creamy, translucent, or light gray to brown in color. They have 2 pair of antennae which are about the same length and 7 pairs of walking legs.
	The larvae of the order Coleoptera (beetles) can be found in group 2 taxa. Body length ranges from 2 to 70mm. They have 3 pair of legs and an obvious head.
	The alderfly larvae and the fishfly larvae belong to the order Megaloptera. The alderfly larva (A.) resembles the dobsonfly (see group 1 taxa) except it has a long, tapering filament fringed with fine hairs extending from its abdomen (see arrow). Its body length ranges from 10-25mm. The fishfly larva (B.) also resembles a small dobsonfly, however, it does not have the gill "tufts" located beneath each of the stout filaments extending out from each of the abdominal segments
	The order Odonata contains the dragonflies (A.) and damselflies (B.). The dragonfly nymphs (some people may call them larvae) are stout bodied with a wide, flat abdomen and large eyes. Their body length ranges from 20-45mm. Damselfly nymphs have a narrower abdomen, large eyes, and 3 leaf-like gills located at the end of the abdomen. Their body length ranges from 20 to 50mm).
	Cranefly (A.) and watersnipe fly (B.) larvae are found in the order Diptera. Cranefly larvae ranges from 10-25mm in body length, has no obvious head capsule or legs, and several finger-like lobes located at the end of its abdomen. Watersnipe fly larvae also has no obvious head capsule or legs, however, they do have short, fleshy outgrowths on each segment of the abdomen, and two longer ones at the end of the abdomen with a fringe of hairs.
	Clams are the last representative of group 2 taxa.

Group 3. Pollution tolerant organisms that can be in any quality of water.	
	Aquatic worms in the phylum Annelida and the class Oligochaeta can vary in body length from 1 to 30mm. They are usually brown in color, but they can be red also.
	Midge fly larvae (A.) and Blackfly larvae (B.) belong to the order Diptera. Midge fly larvae ranges from 2-20mm in body length, usually have an obvious head capsule, and 2 pairs of fleshy, short leg-like appendages, one just behind the head, and one at the end of the abdomen (see arrows). They may also have a fan of hairs at the end of the abdomen. Some can be bright red in color, but they may also vary from white to dark green. Blackfly larvae ranges from 3-15mm in body length, has an obvious head capsule and two distinct clumps of hair located on either side of the mouth (see arrows). They also have one fleshy, short leg-like appendage located just behind the head.
	Leeches are found in the phylum Annelida and the class Hirudinea. They vary in body length from 4-450mm when fully extended. They have soft bodies that are flattened from top to bottom, are usually dark brown and slimy, and they have two distinct suckers, one at the front, and one at the rear (see arrows).
	Pouch snails, pond snails, and other snails are the last representatives of group 3 taxa. Pouch snails and pond snails (A.) have shells that open on the left, while other snails (B.) have shells that coil in a single plane.

Dive In! Bacteria

Bacteria are found everywhere—in the air, water and soil—even in and on our own bodies. Some benefit us by recycling materials or aiding in the production of certain foods, and others are harmful and can cause diseases or spoil our foods.

Total coliform bacteria live in large numbers in the intestines of humans and animals. Coliform bacteria aid in the digestion of food. Fecal coliform bacteria are a sub-group of these microorganisms, of which the most common is Escherichia coli, abbreviated as E. coli. Fecal coliform bacteria are transmitted to water bodies through human and animal feces.

Fecal coliform bacteria are most likely always found in lakes, streams, and other water bodies in low levels, but when high numbers are detected, it can indicate a problem. Swimming in water with high levels of fecal coliform bacteria can cause illness in humans. Sources of this contamination include failing septic systems, sewage treatment system outflows, and domestic and wild animal wastes.

Dive In! Dissolved Oxygen

Dissolved oxygen (DO) refers to the amount of oxygen that is present in the water. Fish and many other aquatic organisms need oxygen just like humans do.

Next time you're near a water body, such as a lake, pond, or stream, take a few notes. Is the water moving or standing still? Are there ripples where the water is rushing over rocks? The more the water is moving and mixing, the more DO is available for fish and other aquatic organisms (Figure 2). If the water is standing still, it contains less DO (Figure 3).

Figure 2. Water is moving and mixing as it passes over the rocks, resulting in a high DO.

Figure 3. Water is standing still, resulting in a lower level of DO.

Oxygen can be present in a water body by way of photosynthesis. Photosynthesis is the process by which plants use energy from the sun, water, and carbon dioxide to make their own food. Aquatic plants take in carbon dioxide during photosynthesis and release oxygen. Oxygen is removed from the water through respiration. Aquatic organisms take in oxygen to breathe and release carbon dioxide.

Other factors, such as temperature and the cloudiness of the water, also affect DO. As the temperature of the water increases, the DO decreases. Soil particles, such as sand, silt, and clay, can make the water cloudy and darker in color. Darker colors absorb more sunlight. When the darker colored water absorbs more sunlight, the temperature of the water increases and the dissolved oxygen decreases.

If the water you are testing has a DO that is too low, fish and other aquatic organisms may be negatively affected (Table 2). If the DO remains too low for a long period of time, fish and other aquatic organisms may move to another spot within the water source or they may die.

Table 2. Effects of DO level on aquatic creatures.

DO level (mg/l)	Effect
>5	Necessary for growth and activity
<3	Deadly for many
3-4	Stressful for many

4-H_2O Tip: You can artificially decrease the oxygen content of a water sample by exhaling into the water sample using a straw.

Dive In! Electrical Conductivity

Electrical conductivity (EC) is used to determine if tiny particles called ions are present in a water sample. Too many or too few ions in a water body can indicate that a more specific test is needed to identify a water quality problem. An example of an ion is nitrate. If too much nitrate is present in a water body, eutrophication may occur. Eutrophication is a process that results in low dissolved oxygen levels, which can be life-threatening for many aquatic organisms. However, too few ions can also indicate a problem. For example, oils from industrial waste or stormwater runoff can reduce the number of ions in a water body. Oils can negatively affect aquatic organisms.

- **Healthy Stream:** 150–500 µS/cm
- **Healthy River:** 150–1500 µS/cm

If a water body has an EC outside of the healthy range, additional tests may be needed to understand why the EC is too high or too low. A high EC may be due to natural factors, such as the surrounding geology of an area, or man-made factors, such as the addition of chemical fertilizers, salts or de-icers. A low EC can also be due to natural factors, such as geology, or human caused conditions, such as agricultural runoff and erosion of ions.

Dive In! Nitrates

Nitrates are found in human and animal wastes, plant materials, soils, fertilizers, and as a result of the burning of fossil fuels.

Nitrogen is essential for plants, animals, and humans. There are several different forms of nitrogen, including nitrate (NO_3^-). If nitrate levels are too low or too high plants, animals and humans can be negatively affected.

- **Healthy water body:** less than 1 mg/l (ppm) of nitrate

If nitrate levels are too high, a process called eutrophication can occur. Eutrophication is when a water body has lots of mineral and organic nutrients, such as nitrate. These mineral and organic nutrients promote an abundance of algae growth. The algae continue to grow more and more until the algae die. When the algae die, the plants sink to the bottom of the water body. The bacteria and other microorganisms in the water body eat all the dead algae. As the bacteria eat more and more of the dead algae, they use up a lot of oxygen in the water. This causes the dissolved oxygen levels in the water to decrease. As the dissolved oxygen levels decrease, other organisms, such as fish and macroinvertebrates, die.

Also, when nitrate levels are too high a condition called methemoglobinemia (also known as blue baby syndrome) can occur in humans. Methemoglobinemia is a blood disorder that weakens the ability of the blood to carry oxygen. The disorder results in a blue appearance of skin and veins due to low oxygen levels. It occurs when nitrate levels are high in drinking water. It mainly effects infants, pregnant women, and the elderly. Brown blood disease is a similar disorder that occurs in fish.

Dive In! pH

pH is used to determine if a water sample is acidic, basic, or neutral (Tables 3-5). Most aquatic organisms can live in waters that have a pH between 5 and 9. However, the optimal range for many aquatic species is a pH between 7 and 8.

Table 3. Acidic, basic, and neutral pH readings.

pH level (0-14)	Reading
<7	Acidic
>7	Basic
7	Neutral

Table 4. pH of everyday items.

Item	pH level
Lemon juice	2.2.–2.4
Natural rain	5.6–6.2
Pure deionized water	7.0
Baking soda	8.4
Household ammonia	11.9

Table 5. Reasons for pH changes in a water body.

Reason	Process
Photosynthesis of aquatic plants	Carbon dioxide reacts with water to form carbonic acid. Plants take in carbon dioxide. Thus, decreasing the amount of carbonic acid in the water.
Respiration of aquatic plants	Carbon dioxide reacts with water to form carbonic acid. Plants give off carbon dioxide during respiration. Thus, increasing the amount of carbonic acid in the water.
Surrounding vegetation	Pine needles are slightly acidic. Decaying pine needles produce organic acids. These organic acids can seep into groundwater or be picked up by runoff during a rainstorm and enter streams, rivers, and other water bodies resulting in a decrease in pH.
Mining, chemical spills, urban runoff, pollution, sewage overflow, and agriculture runoff	Can affect the pH of local water bodies.

Dive In! Phosphates

Phosphates are found in animal and human wastes, industrial and domestic wastes, fertilizers, detergents, soil, and the mineral, apatite.

- **Healthy water body:** less than 0.1 mg/l (ppm) of total phosphates

If phosphate levels are too high, a process called eutrophication can occur. Eutrophication is when a water body has lots of mineral and organic nutrients, such as phosphate. These mineral and organic nutrients promote an abundance of algae growth. The algae continue to grow more and more until the algae die. When the algae die, the plants sink to the bottom of the water body. The bacteria and other microorganisms in the water body eat all the dead algae. As the bacteria eat more and more of the dead algae, they use up a lot of oxygen in the water. This causes the dissolved oxygen levels in the water to decrease. As the dissolved oxygen levels decrease other organisms, such as fish and macroinvertebrates, die.

Dive In! Temperature

Temperature is the hotness or coldness of a substance. If the water body has a temperature that is too high or too low fish and other aquatic organisms that live in the water may be negatively affected (Table 6).

Table 6. Average temperature levels at which aquatic plants and animals can survive.

Temperature	Survival
14° C (57° F)	Many
20° C (68° F)	Some
20° C and < 14° C	Few

Temperature can also affect the levels of dissolved oxygen in the water (Table 7). As the temperature of a water body increases, the dissolved oxygen decreases. Low levels of dissolved oxygen can be life-threatening to certain aquatic organisms.

Table 7. Reasons for temperature changes in a water body.

Reason	Process
Removing vegetation	Removing shade along the banks of a stream, pond or other water body can cause the temperature to increase.
Urban runoff	As water flows over parking lots and paved surfaces, it heats up. As this water or runoff enters a water body, it causes the temperature of that water body to increase.
Groundwater or spring water	Groundwater or spring water colder than a water body enters, decreasing the temperature of that water body.

Dive In! Turbidity

Water samples that are turbid are cloudy and murky, due to natural (such as soil particles) or human (such as industrial runoff) factors. Suspended soil particles and algae are the most common causes of turbid water.

To determine if the water you are testing is cloudy (or turbid) use a black and white disk, called a secchi (sĕk′ē) disk. To make your own secchi disk see the **As Clear as Mud!** activity in this unit.

The secchi disk has a rope attached that is marked every half meter up to 20 meters. A secchi depth reading is obtained by lowering the disk into the water until it cannot be seen, then raising it just until it comes back into view. The average of these depths is the secchi depth. For more information see **Measuring Water Clarity with a Secchi Disk** found in this unit. Record the measurement. The deeper you are able to lower the disk, the less turbid the water (Table 8).

Cloudy or turbid water is generally unhealthy for the invertebrates, fish, plants and other organisms that live in a water body. It can cause the water to absorb more heat and become too warm, reduce the amount of the light that gets to underwater plants, make it difficult for organisms to locate food and can even clog the gills of fish.

Table 8. Water clarity index for north temperate zone lakes.

Water clarity	Secchi depth (ft)
Very poor	3
Poor	5
Fair	7
Good	10
Very good	20
Excellent	32

Source: Wisconsin Department of Natural Resources

Figure 4. Measuring water clarity with a secchi disk.

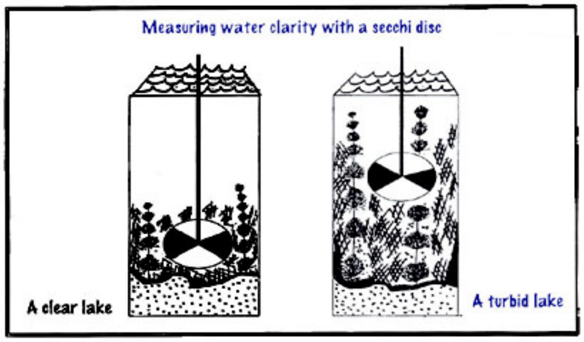


Diagram used with permission from Lake George Association, Inc.

H_2O to Go! Water Quality Assessment

Time: 1 hour

In this activity, youth will conduct chemical water testing and make observations related to the physical characteristics of a local water body.

4-H_2Objectives

- Be able to measure for different chemical water parameters and make observations related to the physical characteristics of a water body.
- Understand the meaning of results collected from chemical testing and physical observations.
- Assess/evaluate the quality of the water body tested.

Materials

- Chemical testing equipment including any safety equipment needed, such as goggles, gloves, etc. Chemical water testing equipment is available at a wide variety of educational supply stores. If a store is not available in your area, search online.
- Copy of **H_2O to Go! Water Quality Assessment** form found in this unit
- Pens/pencils

Instructor Preparation

1. Identify a local water body, such as a stream, river, lake, or pond where youth can visit and conduct sampling. If possible, visit more than one water body for comparison.
2. Read the **H_2O to Go! Water Quality Assessment** form. Identify in advance the information that cannot be obtained from on-site observation. Consult online (http://www.epa.gov/owow/watershed/) or other descriptions of the watershed for additional information.
3. Have youth complete **Perusing the Parameters** activity in this unit.
4. Assemble and become familiar with the equipment that you are going to use for water quality analyses. Read and follow the instructions that accompany every test kit that you plan to use. Test each kit to ensure that it works properly and that the reagents are good. (Some reagents degrade with age.)
5. Take safety precautions as demanded by equipment and chemical use.

Reflection Questions

- Discuss the **H_2O to GO! Water Quality Assessment** form. Based on the observations made, is the quality of the water healthy? Why or why not? For information on chemical testing results see the Dive-In! testing sheets.
- How can the quality of the water be improved?

4-H Life Skills

- **Head:** Learning to Learn, Critical Thinking, and Keeping Records
- **Heart:** Communication, Cooperation and Sharing
- **Hands:** Leadership, Responsible Citizenship, Contributions to a Group Effort, and Teamwork
- **Health:** Self-Responsibility

National Education Standards

Topic	Section	Grade level
1. The Nature of Science	A. The Scientific World View	3-5
	B. Scientific Inquiry	3-5
	C. The Scientific Enterprise	3-8
3. The Nature of Technology	A. Technology and Science	3-8
4. The Physical Setting	B. The Earth	6-8
	C. Processes the Shape the Earth	6-8
5. The Living Environment	A. Diversity of Life	3-5
	D. Interdependence of Life	6-8
	F. Evolution of Life	6-8
9. The Mathematical World	D. Uncertainty	6-8
11. Common Themes	A. Systems	3-8
12. Habits of Mind	A. Values and Attitudes	3-8

H_2O to GO! Water Quality Assessment

Name(s): ____ **Location:** ________________________________

Date/Time: ___________________________ **Water Body:** _______________________________________

Location on Water Body: ____

Weather:

☐ Clear

☐ Overcast

☐ Rain

Overhead Canopy:

☐ Full Shade

☐ Part Shade

☐ Exposed

Current:

☐ Fast

☐ Slow

☐ Still

Bottom Composition:

☐ Bedrock

☐ Boulder

☐ Cobble

☐ Gravel

☐ Sand

☐ Silt

Land Use:

☐ Forestry

☐ Urban Residential

☐ Urban Commercial

☐ Agriculture

☐ Industrial

☐ Mining

Other: _______________

Pollution Indicators

Water Appearance:

☐ Clear

☐ Oily

☐ Green

☐ Foamy

☐ Reddish

☐ Muddy

☐ Tea

☐ Cloudy

Other: _________________

Water Odor:

☐ None

☐ Sewage

☐ Oil

☐ Rotten Eggs

☐ Fish

☐ Chlorine

☐ Acrid/Bitter

Other: _________________

Possible Pollution Sources:

☐ Bank Alterations

☐ Channel Alterations

☐ Storm/Sewer Pipes

☐ Straight Pipes

☐ Waste Water Plant

☐ Construction Sites

☐ Logging Area

☐ Nearby Roads

☐ Livestock/Feedlots

☐ Litter

Other: _________________

Riparian Zone:

Size: ___________________

Vegetation present:

____

____

____

____

Air Temperature: ________

Water Temperature: ______

Dissolved Oxygen (DO): ___________________

Electrical Conductivity (EC): ___________________

Nitrates: ________________

Phosphates: _____________

pH: ____________________

Secchi Depth: ___________

Other Observations/ Measurements:

____

____

____

Catch and Release! Collecting and Identifying Macroinvertebrates

Time: 1 hour

This activity focuses on teaching youth how to collect and identify aquatic macroinvertebrates and determine the water quality based on their findings.

4-H_2Objectives

- Understand what macroinvertebrates are and why they are important.
- Be able to collect macroinvertebrates and identify them using available pictures and keys.
- Determine the quality of a water body (preferably a stream) based on macroinvertebrates collected and identified.

Materials

Per student

- Catch and Release! Macroinvertebrate Tally
- Dive In! Aquatic Macroinvertebrates sheet
- Old shoes
- Net (aquarium nets found at stores such as PetSmart or Walmart work well)

Per group (approximately 20-30 students)

- Dip nets (D-nets)
- Sweeping net (seine net)
- White bucket
- 3 shallow white pans
- 6 ice cube trays (for sorting macroinvertebrates)
- Tweezers or spoons
- Magnifying glasses

Instructions

1. Select an area of a local stream to be sampled. Please note that **Catch and Release! Macroinvertebrate Tally** is designed for stream habitats. However, if a stream is not available, you can use the form with another water body, such as a pond or lake. (The results may not be as accurate.)
2. Sample for 30 minutes (or measure time that works best for your program). Use a small aquarium net, dip net, and/or seine net to collect macroinvertebrates. Use the net to sweep through areas with fallen leaves or aquatic vegetation, and poke the net vigorously around tree root wads and scoop up debris.
3. Place sample material in a white bucket so that you can sort the macroinvertebrates from the organic material and sediments.
4. Sort the organisms, placing similar organisms together in the white pans or ice cube trays.
5. Identify the organisms using the **Dive In! Aquatic Macroinvertebrates** sheet in this unit. If possible have other resources, such as *A Guide to Common Freshwater Invertebrates of North America* book, available for you and youth to use.
6. Record data on the **Catch and Release! Macroinvertebrate Tally**.
7. Record other organisms seen (such as fish, birds, mammals, etc.) and observations made [such as evidence of animals (tracks, scat, etc.), land use (urban, rural, farm, forested, etc.), evidence of humans (litter), etc.)

Recording results on Catch and Release! Macroinvertebrate Tally

8. Place a check mark in the box next to each of the macroinvertebrates found.
9. Count the number of check marks in each column and write that number in the box next to "Number Present" for each column.
10. Multiply the "Number Present" by 3 (Group 1 Taxa), 2 (Group 2 Taxa), or 1 (Group 3 Taxa).
11. Add the values from each column: Column 1 + Column 2 + Column 3 = Total Index Value.
12. Determine if the water body you are testing is poor, fair, good, or excellent based on the Total Index Value.
13. Record other organisms seen or observations made in the corresponding spaces.

The index values and water quality ratings are based on the number of different kinds of macroinvertebrates collected rather than the number of individual specimens collected. A sampling site showing a variety of different kinds of macroinvertebrates indicates good water quality. Poor water quality may be indicated by large numbers of only a few kinds of macroinvertebrates.

Reflection Questions

- Is the water quality poor, fair, good, or excellent based on the macroinvertebrates collected?
- Based on other observations made (and other organisms seen) what can you conclude about the quality of the water? Why?

4-H Life Skills

- **Head:** Learning to Learn, Critical Thinking, and Keeping Records
- **Heart:** Communication, Cooperation and Sharing
- **Hands:** Leadership, Responsible Citizenship, Contributions to a Group Effort, and Teamwork
- **Health:** Self-Responsibility

National Education Standards		
Topic	**Section**	**Grade level**
1. The Nature of Science	A. The Scientific World View	3-5
	B. Scientific Inquiry	3-5
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3. The Nature of Technology	A. Technology and Science	3-8
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	C. Processes the Shape the Earth	6-8
5. The Living Environment	A. Diversity of Life	3-5
	D. Interdependence of Life	6-8
	F. Evolution of Life	6-8
9. The Mathematical World	D. Uncertainty	6-8
11. Common Themes	A. Systems	3-8
	C. Constancy and Change	6-8
12. Habits of Mind	A. Values and Attitudes	3-8

Catch and Release!

Macroinvertebrate Tally for Stream Habitats

Location: ____

Form completed by: ____

Date: ____ **Time (am or pm):** ____________

Purpose: ____

Group 1 Taxa	**Present**	**Group 2 Taxa**	**Present**	**Group 3 Taxa**	**Present**
Water penny larvae		Damselfly nymphs		Blackfly larvae	
Mayfly nymph		Dragonfly nymphs		Aquatic worms	
Stonefly nymph		Cranefly larvae		Midge larvae	
Dobsonfly larvae		Beetle larvae		Left-hand snails	
Caddisfly larvae		Crayfish		Leeches	
Riffle beetle adults		Scuds			
Right-hand snails		Clams			
		Sowbugs/ Isopods			
Number present=		Number present=		Number present=	
Multiply by 3=		Multiply by 2=		Multiply by 1=	

Add the values from each column: Column 1 + Column 2 + Column 3 = Total Index Value

______ + ______ + ______ = ________

Water Quality Assessment:

oor = < 11 ____ Good = 17-22 ____

Fair = 12-16 ____ Excellent = > 23 ____

Other organisms seen:

Other observations:

All Things Are Connected

Loosely adapted from a folk tale heard around the campfire by Martha M. Yount, University of Kentucky Cooperative Extension Service.

Time: 15–20 minutes

In this activity, youth are given roles as characters in a story. The story teaches youth that all things are connected.

4-H_2Objectives

Youth understand that all things are connected and that each organism plays an important role in our ecosystem.

Materials

- Index cards with roles of various characters in the story (roles listed below)

Instructions

1. Assign each student a role in the story.

Characters

- **Queen:** Stand and give a royal wave
- **Bull frogs**: Jug-o-rum, jug-o-rum
- **Upland chorus frogs:** Ribbett, ribbett
- **Spring Peepers:** Peep, peep, peep
- **Council members:** Yes, your Majesty! Of course, your Majesty! Whatever you say, your Majesty!
- **New sound:** Bzz, bzz, bzz
- **Wise newcomer:** "All things are connected"

Optional characters

- **Window:** Creeeaaakkkk
- **Sunset:** Aaahhhh

2. Explain to students that when they hear the name of their character in the story, they should then do their role or part. For example, the role of the queen is to stand and give a royal wave. As the story is being read, each time the queen is mentioned the student portraying her should stand and wave.
3. After explaining and assigning roles, read the story out loud to the students, having them each do their assigned parts.

Story

Once upon a time there was a beautiful land full of happy and contented people. Every evening, just as the day was ending, they would fling open their **windows**, watch the beautiful **sunset**, and listen to the wonderful night music. There were **bull frogs**, **upland chorus frogs**, and **spring peepers**. When all the **frogs** sang together, it made a beautiful concert.

Now, in this land, there was a **queen**. She was a good **queen**, but all the people were afraid to disagree with her because they didn't want to hurt her feelings. So, no matter what she said to her **council members**, they always agreed with the **queen**. One day a **wise newcomer** moved into the kingdom. No one really understood the **wise newcomer**, but she did seem to be wise, so the **queen** invited the **wise newcomer** to be an advisor with her **council members**. Life was good in the kingdom, and each evening the people flung open their **windows**, watched the beautiful **sunset**, and listened to the wonderful concert of the **frogs**.

One night, the **queen**, who had been a little grumpy all that day because she had lost her favorite marble, had bad dreams and just didn't sleep well at all. The next day, she called a council meeting. "**Council Members**!" the **queen** said. "Last night, I didn't sleep at all. I think it was all those **bull frogs** singing so loud. I think we should gather up all the **bull frogs** and send them to the kingdom to the east. What do you think, **council members**? What about you, **wise newcomer**?" Since the **council members** were in the majority and no one really understood what the **wise newcomer** meant anyway, all the **bull frogs** were gathered up and sent to the kingdom in the east.

That evening, the **queen** flung open her **window** as usual. The **sunset** was just as beautiful as it always was, but the night concert wasn't quite the same. She still heard the **upland chorus frogs** and the **spring peepers**, but she also heard a quiet **new sound**. (Swat as if at a mosquito.) The **queen** went to bed and slept poorly again. The next morning, the **queen** called a council meeting again. "**Council Members**!" the **queen** said. "Last night, I didn't sleep again. I think it was all those **upland chorus frogs** singing so loud. I think we should gather up all the **upland chorus frogs** and send them to the kingdom to the south. What do you think**, council members**? What about you, **wise newcomer**?" Since the **council members** were still in the majority and no one really understood what the **wise newcomer** meant anyway, all the **upland chorus frogs** were gathered up and sent to the kingdom in the south.

That evening, the **queen** sighed and opened her **window**. Yes, the **sunset** was just as beautiful, but the night concert had changed again. She heard the **spring peepers**, but the **new sound** was louder. (Swat as if at several mosquitoes.) The **queen** went to bed and tossed and turned all night long. The next morning, the **queen** called yet another council meeting. "**Council Members**!" the **queen** said. "Last night, I didn't sleep a wink. It must be all those **spring peepers** singing so loud. I think we should gather up all the **spring peepers** and send them to the kingdom to the west. What do you think, **council members**? What about you, **wise newcomer**?" The **council members** were still in the majority and no one understood what the **wise newcomer** meant anyway, so all the **spring peepers** were gathered up and sent to the kingdom in the west.

That night, the **queen** was almost afraid to open her **window** at all, but she cautiously opened it anyway and peeked out. She didn't hear any **frogs**, so she flung the **window** open. There was the beautiful **sunset**, and a very loud **new sound**! (Swat as if at many mosquitoes.) The **queen** ran to her bed, jumped in and pulled the covers up over her head.

The next morning, the **queen** was very grumpy and all bleary eyed. "I still can't sleep and I look a fright!" she said to her **council members**. "All the **frogs** are gone but I still can't sleep! And now I have all these itchy bug bites..."

The **wise newcomer** stood and spoke to the **council members**. The **queen** got a very puzzled look on her face, then she realized what the **wise newcomer** meant! (Do you?) "**Council members**! Bring back the **bull frogs** from the kingdom to the east, and the **upland chorus frogs** from the kingdom to the south, and the **spring peepers** from the kingdom to the west!"

That evening, the **queen** went to her **window** once again. She opened it and looked out on the beautiful **sunset** and was so happy to once again hear the wonderful night concert of the **frogs**. The **queen** smiled and went to bed. As she pulled the covers back, there was a loud thump as something rolled out of the bed and onto the floor. "My favorite marble!" said the **queen**. "So that's why there was a lump in my bed that kept me from sleeping!"

The **wise newcomer** moved along to another town, and the people of the kingdom once again flung open their **windows** and listened to the wonderful night music of the **frogs**. The **new sound** was hardly ever heard again, and the people always remembered the words of the **wise newcomer**....

Reflection Questions

- What was the "new sound" and why did it get louder and louder? *The new sound was the buzzing of mosquitoes. The buzzing got louder and louder when the queen got rid of all the frogs. Frogs eat mosquitoes.* Without the frogs to eat the mosquitoes, the mosquito population increased.
- What did the wise newcomer mean when he/she said "all things are connected"? *That each organism plays an important role in the ecosystem. If one organism is removed from the system, the system will be impacted and change.*

4-H$_2$Opportunities

Have students create their own stories about how all things are connected. Read stories out loud as a group.

4-H Life Skills

- **Head:** Learning to Learn, Critical Thinking, and Keeping Records
- **Heart:** Communication, Cooperation and Sharing

National Education Standards		
Topic	**Section**	**Grade level**
5. The Living Environment	D. Interdependence of Life	6-8
11. Common Themes	A. Systems	3-8
	C. Constancy and Change	6-8

Diving Deeper

M.U.D. Puppies: Making Underwater Discoveries

M.U.D. Puppies activity used, with permission, from Martha Yount, University of Kentucky Cooperative Extension Service.

Time: 45 minutes (not including travel time to/from water body)

In this activity, youth are assigned various roles, such as biologist, chemist, art photographer, etc. With each assigned role comes responsibilities that youth must perform during a stream study. This activity requires the use of a stream.

4-H_2Objectives

- Learn different career opportunities related to scientific investigations.
- Understand how to measure for different chemical and biological water parameters.

Materials

- Old shoes or rubber boots
- One badge per student. (Make copies of the name tag graphics in Figure 5, cut apart and place in nametag holders). Note: Save old nametag holders and lanyards from past conferences and events.
- Water testing equipment, such as PRIDE Clean Stream Kit, Lamotte, and/or Hach testing equipment
- Net (aquarium nets found at stores such as Pet Smart or Walmart work well in most cases)—one per biologist
- Dip nets (D-nets) and sweeping net (seine net)—optional
- 3 shallow white basins/pans (such as a dish pan)
- 6 ice cube trays (for sorting macroinvertebrates)
- Tweezers, spoons, and magnifying glasses
- Access to stream
- Pens/pencils and paper for recording results
- Cameras (for photojournalists and art photographer)
- Underwater camera (for underwater photographer)—if available
- Copies of **Dive In! Aquatic Macroinvertebrates** sheet, Catch and Release! Macroinvertebrate Tally and H_2O to Go! Water Quality Assessment form to record results (all found in this unit)

Remember safety rules when testing near a water body. An adult should always be present. Life jackets may or may not be needed depending on each individual situation. Please use your best judgment.

Instructions

1. Select a nearby stream that is shallow, easy to access, and unpolluted. (Contact your state water quality coordinator for information regarding water quality of local streams and water bodies.)
2. Assign each student a role. Some roles may be assigned to more than one student.

Roles

- Biologists use nets and basins/pans to collect macroinvertebrates. For more information on biological water testing see Perusing the Parameters in this unit. Biologists record results on **Catch and Release! Macroinvertebrate Tally**.
- Chemists and lab assistants conduct simple chemical tests (such as pH, temperature, and dissolved oxygen). For more information on chemical water testing see **Perusing the Parameters** in this unit. Chemist and lab assistants record results on **H_2O to Go! Water Quality Assessment** form.
- Field technicians collect water samples for testing.
- Photojournalists take pictures documenting the trip and activities.
- Art photographers take pictures of nature.
- Underwater photographers use underwater cameras to take photographs.
- OSHA representative is the chaperone (adult) and ensures all safety procedures are followed.

3. Give each student the assigned “badge” (job/role).
4. After conducting the stream study discuss the data collected. Allow students to share their findings (data, photographs, etc.) with the group.

Note: Provide students with rubber boots if available, or tell students in advance to bring old shoes. No bare feet in the stream!

M.U.D Puppies Making Underwater Discoveries BIOLOGIST	M.U.D Puppies Making Underwater Discoveries CHEMIST
M.U.D Puppies Making Underwater Discoveries LAB TECHNICIAN	M.U.D Puppies Making Underwater Discoveries FIELD TECHNICIAN
M.U.D Puppies Making Underwater Discoveries PHOTO JOURNALIST	M.U.D Puppies Making Underwater Discoveries ART PHOTOGRAPHER
M.U.D Puppies Making Underwater Discoveries UNDERWATER PHOTOGRAPHER	M.U.D Puppies Making Underwater Discoveries O.S.H.A. REPRESENTATIVE

Figure 5. M.U.D. Puppies name badges.

Reflection Questions

- Based on other observations made (chemical and biological water testing, photographs taken, etc.) what can you conclude about the quality of the water? Why?
- How can the quality of the water be improved?

4-H_2Opportunities

Have students test the stream during different periods of the year (such as once each season). Have students compare and contrasts their results and observations. Host a Water Celebration featuring the students' findings, including data, photographs, etc. Have students serve as docents during the event to explain the various exhibits to visitors. Serve goldfish crackers and pond punch (any kind of blue-colored drink).

4-H Life Skills

- **Head:** Learning to Learn, Critical Thinking, and Keeping Records
- **Heart:** Communication, Cooperation and Sharing
- **Hands:** Leadership, Responsible Citizenship, Contributions to a Group Effort, and Teamwork
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	C. Constancy and Change	6-8
12. Habits of Mind	A. Values and Attitudes	3-8

As Clear as Mud! Water Clarity

This activity focuses on water clarity and turbidity. Youth will learn what a secchi disk is, how to create a secchi disk, how to measure secchi depth, and how secchi depth relates to water quality.

4-H_2Objectives

- Define water clarity and turbidity
- Identify sources of turbidity
- Understand what a secchi disk is and what it is used for
- Understand what secchi depth is and how it relates to water quality

Water Clarity

Water clarity is a measure of how clear or transparent the water is in a water body. Turbidity measures the amount of particulate matter suspended in water. Suspended soil particles and algae are the most common causes of turbid water. Cloudy or turbid water is generally unhealthy for the invertebrates, fish, plants and other organisms that live in a water body. It can cause the water to absorb more heat and become too warm, reduce the amount of the light that gets to underwater plants and can even clog the gills of fish. Water clarity can be measured using a simple device --the secchi disk (Figure 6).

A secchi disk consists of a weighted circular disk with alternating black and white quarters painted on the surface. The disk is attached to a rope or chain that has been calibrated in increments (feet or meters). A secchi depth reading is obtained by lowering the disk into the water until it cannot be seen, then raising it just until it comes back into view. The average of these depths is the secchi depth.

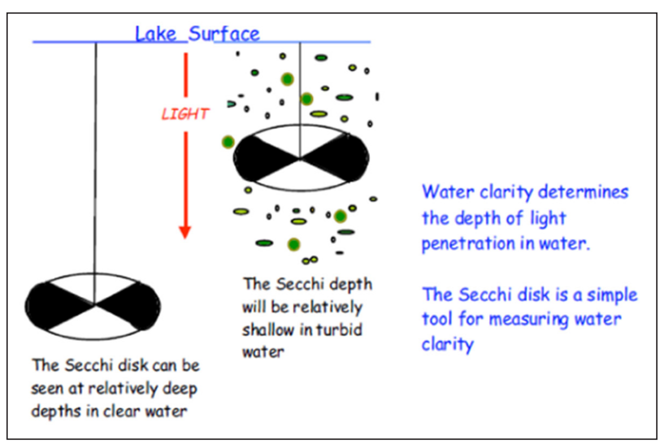

Figure 6. Water clarity can be measured using a secchi disk.

A secchi reading by itself cannot tell you what types of suspended particles are causing changes in water clarity. Many types of suspended particles can affect secchi readings, these include: algae, suspended sediments, and any other particulate material. Secchi readings taken in very dark-colored waters, such as in some coastal plain lakes, may inaccurately estimate water clarity. The dark water may cause a shallower reading than is appropriate for the amount of particulate matter.

The value of your secchi disk observations is improved if you note the apparent water color. Very green water usually indicates the presence of algae growth. Brown or reddish-colored turbid water is most often caused by suspended sediments and clay. The benefit of secchi depth readings is that they can be compared to other readings from lakes throughout the world. The annual Great North American Secchi Dip-In, usually held in the two weeks around the Fourth of July, invites participants from throughout the world to measure secchi depths in local water bodies and register their results on the Secchi Dip-In website: http://dipin.kent.edu/.

Water clarity values do not always correspond to water quality. The values in Table 8 assume that all or most of the increase in turbidity (and decrease in secchi depth) is due to growths of algae. In lakes that are affected by abundant suspended sediments, water clarity may be poor at times, yet the overall water quality may be good.

Making a Secchi Disk

Materials

Per student

- Metal or plastic disk about 8 inches (20 cm) in diameter, with a hole in the center
- One eye-bolt and one or two nuts
- Metal weight or 5 fender washers
- Shrink resistant braided nylon rope (at least 6 meters)

Per group (3 students)

- Permanent markers (red and black)
- Measuring stick or tape (meters and inches)

People have reported using disks made from a wide variety of materials that yield similar results to those made with a metal disk. Solid wood can work if using a heavy metal weight but you'll need to paint it with black and white flat enamel paint. White CDs also work; paint two quarters with a black permanent marker. In general, disks made from lighter materials need a heavier metal weight.

Instructions

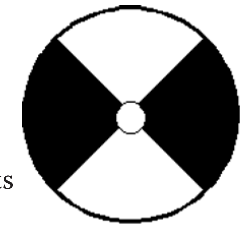

Figure 7. Black and white pattern on secchi disk.

1. Divide the disk in 4 parts by drawing an "X" so that you have 4 equal parts.
2. Using a black permanent marker, color 2 opposite parts of the disk (Figure 7).
3. Place the eye-bolt on top of the disk and the metal weight or fender washers underneath the disk (the unpainted part) and secure it with the bolts, and washers (Figure 8).

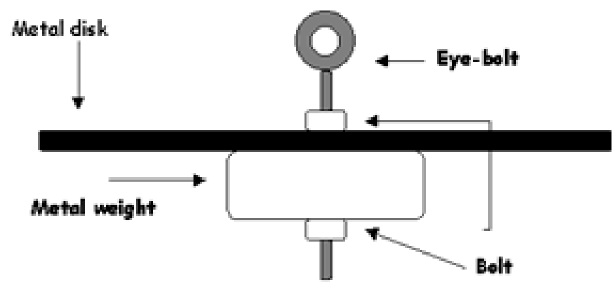

Figure 8. Method for assembling hardware on secchi disk.

4. Attach the rope to the eye-bolt, securing it with a safe knot.
5. Place the disk on the floor and lay down your measuring stick parallel to the rope. Start marking the rope from the surface of the secchi disk.
6. Mark the rope using a black marker for "feet" and a red marker for "meters." If you want very precise measurements mark the rope in 10th of meters.
7. Have fun using your secchi disk!

Measuring Water Clarity with a Secchi Disk

Instructions

1. Explain what water quality is and why it is important. Define water clarity and explain that water clarity can be used as an indicator of water quality.
2. Explain how a secchi disk is used and what type of information a secchi disk can provide about water quality.

3. Demonstrate how to assemble a secchi disk.
4. Demonstrate use of a secchi disk.
5. Position yourself on a long dock or on a boat, over deep water. The water should be deep enough that you cannot see the bottom of the lake.
6. Lower the disk slowly into the water until it disappears, avoiding any glare.
7. To allow your eyes to completely adapt to the light level, allow sufficient time (approximately one or two minutes) when looking at the disk as it disappears.
8. Mark the depth at which the secchi disk disappears from view, by clipping a clothespin to the line.
9. Slowly raise the disk until it just becomes visible again and mark the depth at which the secchi disk reappears. Clip a second clothespin to the line.
10. Record the depths at which the secchi disk disappeared and reappeared. Average these two depths to find the secchi depth.
11. Repeat the procedure at least twice to ensure an accurate measurement.
12. If the two readings are very different, you may have to repeat lowering and raising the disk until you get consistent measurements.
13. Compare your readings with Table 8. Remember that just one test will not tell you much about the overall quality of a body of water, nor do these values specify overall water quality.

Secchi readings tell you more about the water body when compared over time. Try to start collecting this information every year. If collected around the same time every year, this information combined with that gathered from other water quality tests will allow you to make conclusions as to the quality and health of a water body.

4-H_2O Tip: Secchi depth readings taken from a single water body for several months, or a selection of water bodies in a short time frame, can be part of a unique science fair project. You can compare your secchi disk readings to others taken all over the world at the Secchi Dip-In web site, http://dipin.kent.edu/.

Reflection Questions

- How did the group's secchi depth reading compare to Table 8? *Discuss the water clarity of the water body. Is it very poor, poor, fair, etc., based on the secchi depth. Discuss why. If the water body is very poor, is this due to erosion, algae growth, etc.? Discuss the land use around the water body. Is the land use agricultural, urban, rural, etc.? Discuss how this might affect the water clarity.*
- How might the secchi depth reading change after a rain event? *Answers will vary based on the water body you are testing. A rain event may negatively affect the water clarity, especially if the banks of the water body are bare soil and not vegetated. Erosion may occur resulting in muddy, cloudy water.*

Measuring Water Clarity Classroom Alternative

If the weather, student numbers, or lack of a nearby water body prevents you from using a secchi disk outdoors, you can alternatively do it indoors.

Materials

- Three 10 gallon plastic containers
- Approximately 10 gallons of lake or pond water, preferably with algae
- Approximately 10 gallons of water mixed with soil
- Approximately 10 gallons of tap or rain water
- Three 13 gallon white trash cans, labeled Sample 1, 2, and 3
- At least 3 secchi disks
- Materials to develop one secchi disk with youth (see **Instructions for Making a Secchi Disk** in this unit.)
- Cloth pins (two for every secchi disk)
- Optional: Water clarity index table for north temperate zone lakes showing real data or data from a local water body

Instructions

1. Prior to the activity, label trash cans Sample 1, Sample 2, and Sample 3. Collect water samples described in materials list and place in trash cans for 4-H to assess.

2. Explain to 4-Hers what water quality is and why it is important. Define water clarity and explain that water clarity can be used as an indicator of water quality.
3. Explain how a secchi disk is used and what type of information a secchi disk can provide about water quality.
4. Demonstrate how to assemble a secchi disk.
5. Demonstrate use of a secchi disk. Remind students that the disk should be slowly dropped perpendicular to the water and that they should wait at least a few seconds until they see the disk disappear before marking the secchi depth.
6. Allow students to try the secchi disk themselves using the 3 water samples. Allow only 3 students (one at each station) at a time and provide a related activity for the rest of the class while they wait.
7. Have students record secchi disk readings.

Reflection Questions for Classroom Alternative

- Were the secchi depths different or the same for the three water samples? Discuss. *The secchi depths were different due to amount of soil particles and algae suspended in the water.*
- What may have caused differences in the secchi depths? *Differences in depths could have been related to where the samples were collected. Nearby land use (agricultural vs. urban) could have affected the amount of suspended solids in each water sample. Soil particles could have resulted from erosion. Increased algae blooms could have resulted from runoff rich in nutrients entering the water body, such as runoff polluted with fertilizers and pet waste.*
- How can you relate this to a real life scenario? *Discuss local water bodies. Discuss possible sources of pollution in your community that might result in a low secchi depth and how that might affect people, animals, and plants that live in the community.*
- Discuss ways to decrease erosion and other sources of pollution that would affect secchi depth. *Decrease erosion, plant vegetation on areas of bare soil, decrease polluted runoff, apply fertilizers properly, pick up pet waste. The ideas are endless!*

4H_2Opportunity

Collect water samples from local water bodies, such as a lake, stream, pond, or wetland before class. Conduct the activity using these water samples. Compare the clarity and secchi depth.

Muddy Water

Muddy Water activity used, with permission, from Martha Yount, University of Kentucky Cooperative Extension Service.

Time: 30 minutes

Students will learn about turbidity and the use of a secchi disk using edible ingredients.

Materials

- 8 cups of water
- ⅓ cup cocoa
- ⅓ cup chocolate chips
- ½ tsp green sugar
- 1 cup powdered sugar
- 1⅓ cup dry milk powder
- ⅓ cup non dairy creamer
- Marshmallows
- Coffee stir sticks
- Microwave
- Wire whisk
- 2 quart clear measuring bowl

Instructions

1. Pour water into a clear 2 quart measuring bowl. Discuss with youth that the water in a healthy body of water is not sterile.
2. Add chocolate chips. Tell youth that the chocolate chips represent rocks and pebbles on the bottom of a water body. The rocks and pebbles provide habitat for aquatic insects and shelter for fish eggs, both important parts of the food chain.
3. Add green sugar. Tell youth that the green sugar represents small aquatic plants and algae which are also an important part of the ecosystem.
4. Stick marshmallow on end of coffee stir stick. This represents a secchi disk. Discuss with youth the terms *sediment* and *turbidity*. Sediment and turbidity are two similar terms, but they aren't exactly alike. Sediment is solids in the water. Some sediment might settle to the bottom, leaving the water clear (not turbid) or

remain suspended in the water (increasing the turbidity.) A simple tool to measure turbidity, or the amount of suspended particles in the water, is a secchi disk. A secchi disk is a black and white circle that is lowered into the water using a measured rope. The depth at which the disk disappears from sight gives us an indication of the turbidity level of the water. Our secchi disk for this experiment is a marshmallow stuck on a coffee stir stick. Even though the water is green from the algae, we still see the marshmallow even when it is lowered to the bottom of the bowl.

5. Now let's add some sediment to our body of water. Add powdered sugar. Discuss with youth that sediment comes from many sources (fertilizer, industrial waste, and plain old dirt.) Sediment is the number one contaminant in Kentucky's waterways. How does sediment get into the water? (Dumped in or near a stream, straight pipes, washed in from stream banks, storm water runoff). Some sediment dissolves in the water. Even though we can't see it, it is still there. (Use secchi disk again.)
6. Add powdered milk. Discuss with youth that some sediment settles to the bottom. Enough sediment covers up the rocks and smothers fish eggs and smaller members of the ecosystem.
7. Add creamer and cocoa. Discuss with youth that some sediment stays suspended in the water or even floats on top. (Use secchi disk again.) Dark sediment absorbs heat from the sun and raises the temperature of the water, which can harm fish and other living things. (Heat in the microwave 6 minutes.)
8. Stir up the mixture. Serve the hot cocoa to the group as they brainstorm ways to keep sediment out of our waterways. (Buffer zones, baffles or fences for construction, no dumping in storm drains, etc.)

4-H Life Skills

- **Head:** Learning to Learn, Critical Thinking, and Keeping Records
- **Heart:** Communication, Cooperation and Sharing
- **Hands:** Leadership, Responsible Citizenship, Contributions to a Group Effort, and Teamwork
- **Health:** Self-Responsibility

National Education Standards		
Topic	**Section**	**Grade level**
1. The Nature of Science	A. The Scientific World View	3-5
	B. Scientific Inquiry	3-5
	C. The Scientific Enterprise	3-8
3. The Nature of Technology	A. Technology and Science	3-8
4. The Physical Setting	B. The Earth	6-8
	C. Processes the Shape the Earth	6-8
5. The Living Environment	A. Diversity of Life	3-8
	D. Interdependence of Life	3-8
	F. Evolution of Life	6-8
9. The Mathematical World	D. Uncertainty	6-8
11. Common Themes	A. Systems	3-8
	C. Constancy and Change	6-8
12. Habits of Mind	A. Values and Attitudes	3-8

The Human pH Meter

Time: 1 to 1½ hours

This activity will introduce youth to the concept of pH using common substances.

4-H_2Objectives

- Understand the pH scale and what it measures.
- Identify common substances that are acidic, basic, or neutral.

pH

pH is a measure of how acidic or basic a solution is. The pH scale ranges from 0 to 14. A value of 7 represents a solution that is neutral. Values greater than 7 indicate alkaline or basic solutions; values less than 7 indicate acidic solutions. The recommended pH of drinking water is 6.5-8.5. The optimal pH range for fish and other aquatic life is 7.0-8.0. If a water body has a pH outside of this range it can be stressful to the organisms living there. Water bodies with a pH of less than 5 or greater than 9 are unable to support most aquatic life. The scale in Table 10 shows approximate pH levels of some familiar substances.

Table 10. pH Scale.

Acidic	0	
	1	Stomach acid
	2	Lemon juice
	3	Soft drinks
	4	Acid rain
	5	Natural rain
	6	Milk
Neutral	7	Pure deionized water
	8	Sea water
	9	
	10	Household ammonia
	11	
	12	Bleach
	13	
Basic	14	Drain cleaner

Materials

- 12 small cups (such as mouthwash rinse cups)
- 2 sets (one set blue and one set red) of 12 pieces of construction paper cut into squares to use as ballots
- 1 poster board (22″ x 28″) (size may vary depending on number of youth participating)
- 1 piece of non-translucent material to use for covering part of the cardboard
- Masking tape
- 1 permanent marker
- At least one pH kit*
- About 1 cup of each of the following substances (suitable for drinking):
  - Lemon juice
  - Drinking water
  - Milk
  - Tomato juice or black coffee
  - Coca cola (regular)
  - Orange or apple juice

*pH paper or pH test strips can be found in many parent/teacher stores inexpensively and are easy to use.

Instructor Preparation

1. On the poster board draw a table with 3 columns and 13 rows, and label the rows and columns as shown. Make a copy of the table on a regular sheet of paper and use it to record which substances were poured in which cup numbers.

Cup #	Judge's Verdict	pH
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

2. Using a permanent marker label the cups 1 through 12.
3. Partially fill each cup with the designated substance. Note that there should be two cups of each substance.

Instructions

1. Ask for 12 volunteers. Tell the volunteers that they are now scientific instruments.
2. Give each volunteer a pair of ballots, one red and one blue (Figure 9).

Figure 9. Ballots.

3. Explain to the entire class that red equals acidic and blue equals not acid (or alkaline). Discuss pH, what it measures, and why it is important to water quality. See **Dive In! pH** for additional information on pH and water quality.
4. Ask volunteers to taste the substance in one cup. After sampling, have each volunteer attach their ballot (blue = bitter; red = sour) to the Judge's verdict column on the poster board using tape.
5. Reveal what each substance is (for example, cup #1 = lemon juice).
6. Using a pH kit, measure the pH of each substance (Table 11).

Table 11. pH levels of common substances.

Sample	Judge's verdict	pH
Lemon juice		2
Milk		6.5
Soft drink		3
Drinking water		7
Tomato juice		4
Black coffee		5
Orange juice		3-3.5
Apple juice		3.5-4

Reflection Questions

- Was each of the judges' verdicts for each substance the same? Discuss why individuals may have chosen different ballots for different substances.
- How does pH affect water quality, and the plants and animals that live in the water? See **Dive In! pH** for more information on pH and water quality.

4-H Life Skills

- **Head:** Learning to Learn, Critical Thinking, and Keeping Records
- **Heart:** Communication, Cooperation and Sharing

National Education Standards		
Topic	**Section**	**Grade level**
1. The Nature of Science	A. The Scientific World View	3-5
	B. Scientific Inquiry	3-5
	C. The Scientific Enterprise	3-8
3. The Nature of Technology	A. Technology and Science	3-8
4. The Physical Setting	B. The Earth	6-8
	C. Processes the Shape the Earth	6-8
5. The Living Environment	D. Interdependence of Life	3-8
	F. Evolution of Life	6-8

Build a Bug

Build a Bug activity was adapted and used, with permission, from Nancy Mesner, Utah State University.

Time: 20 minutes

To introduce students to macroinvertebrates and the adaptations they have which allow them to live in an aquatic environment.

4-H_2Objectives

- Understand what an aquatic macroinvertebrate is.
- Define adaptation.
- Identify different adaptations aquatic macroinvertebrates have that enable them to survive in their environment.

Aquatic Macroinvertebrates

See **Dive In! Aquatic Macroinvertebrates.**

Macroinvertebrates have many special adaptations, allowing them to live in demanding environments. Macroinvertebrates that live in riffles and fast-moving water may have features that help them hold on to rocky or hard substrates, such as hooked feet, suction cups, and flat bodies. Macroinvertebrates that house themselves deep in muddy substrates may have adaptations for a low oxygen environment. See the adaptations column of Table 12 for more examples.

Table 12. Adaptation of macroinvertebrates.

Adaptation	How macroinvertebrate uses adaptation	Item representing adaptation
Legs/Claws	Swimming, holding onto slippery or rocky materials, catching prey	Water noodle with hooks on end (fake fingernails [from Halloween] also work well for claws.)
Tails	Swimming, navigating	Garland or rope
Compound eyes	Seeing in water	Sunglasses with craft eyes glued on
Sensory hair on head	Sense vibrations in the water; for example vibrations help them tell if a predator is coming	Wig or furry hat
Gills	Breathing	Feather boa
Antennae	Sense vibrations in the water	Purchased or homemade antennae
Air bubble (plastron)	Breathing	Balloon
Air tube	Breathing	Straw
Specialized mouth parts	Feeding and catching prey	Fake vampire teeth and/or fishing net

Materials

Items listed in the "item representing adaptation" column in Table 12.

Instructions

1. Ask youth to brainstorm different adaptations a bug would need to live in an aquatic environment. For younger 4-Hers explain what an adaptation is. An organism may modify or change one or more of its parts so that it can live in a certain environment.
2. Choose one volunteer from the group. Explain that you will be preparing the volunteer to live as an aquatic macroinvertebrate.
3. Ask the youth to tell you adaptations the volunteer would need to live under water.
4. As the youth tell you different adaptation ideas, dress the volunteer in the items that represent that adaptation.
5. Discuss the adaptations as you go along. Why would a macroinvertebrate need these adaptations? How do they help a macroinvertebrate survive?

Note: An individual macroinvertebrate may not have all the adaptations listed in the chart. Your volunteer "bug" will have features found on many different types of macroinvertebrates.

Reflection Question

- Discuss the importance of macroinvertebrates. Do fish need them? Do we need them? How do they help us?

4-H Life Skills

- **Head:** Learning to Learn, Critical Thinking, and Keeping Records
- **Heart:** Communication, Cooperation and Sharing

National Education Standards

Topic	Section	Grade level
1. The Nature of Science	B. Scientific Inquiry	3-5
3. The Nature of Technology	A. Technology and Science	3-8
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	D. Interdependence of Life	3-8
	F. Evolution of Life	6-8

Sink or Swim

Conduct a pre- and post-questionnaire

Ask youth the following questions before and after the activities to determine if youth's knowledge level changed.

- What is water quality?
- How is water quality measured?
- What are macroinvertrebrates and why are they important?
- Is bacteria a measure of water quality? Explain.
- What is:
  - Dissolved oxygen
  - Electrical conductivity
  - Nitrate
  - Phosphate
  - pH
  - Temperature
  - Turbidity
- How do each of the measurements listed above relate to water quality?
- What other types of observations can be when studying a water body? *Answer: physical observations; see* ***H_2O to GO! Water Quality Assessment*** *form.*

Develop a K-W-L Chart

This chart demonstrates what students **k**now about the subject before the activity, what students **w**ant to know about the subject during the activity, and what students **l**earned about the subject after the activity. Before starting the activity ask youth as a group what they **k**now about watersheds. Once they have told you what they already know, ask them what they **w**ant to know about watersheds. Record all answers/comments on large poster board or chalk board to refer back to. This section will help the leader know what areas of the activities to emphasize. Depending on these comments the leader may have to adapt the activities to ensure that the youth learn items they have specified in this section. After the activities discuss what the youth **l**earned. Go back to the first and second questions of the chart and discuss what they knew (were their statements correct?, etc.) and make sure items that youth wanted to know were addressed.

Glossary

Acidic. The condition of water or soil that contains a sufficient amount of acid substances to lower the pH below 7.0.

Adaptation. Changes in an organism's physiological structure or function or habits that allow it to survive in new surroundings.

Algae. Simple rootless plants that grow in sunlit waters in proportion to the amount of available nutrients. They can affect water quality adversely by lowering the dissolved oxygen in the water. They are food for fish and small aquatic animals.

Algal blooms. Sudden spurts of algal growth, which can affect water quality adversely and indicate potentially hazardous changes in local water chemistry.

Alkaline. The condition of water or soil that contains a sufficient amount of alkali substance to raise the pH above 7.0.

Alkalinity. The capacity of bases to neutralize acids. An example is lime added to lakes to decrease acidity.

Anti-degradation clause. Part of federal air quality and water quality requirements prohibiting deterioration where pollution levels are above the legal limit.

Aquatic macroinvertebrate. An invertebrate that is large enough to see with the naked eye that lives in aquatic environments.

Bacteria (singular: bacterium). Microscopic living organisms that can aid in pollution control by metabolizing organic matter in sewage, oil spills or other pollutants. However, bacteria in soil, water or air can also cause human, animal and plant health problems.

Baffle. A flat board or plate, deflector, guide, or similar device constructed or placed in flowing water or slurry systems to cause more uniform flow velocities to absorb energy and to divert, guide, or agitate liquids.

Base. Often used as a synonym for alkali. See alkaline and alkalinity.

Benthic/Benthos. An organism that feeds on the sediment at the bottom of a water body such as an ocean, lake, or river.

Coliform organism. Microorganisms found in the intestinal tract of humans and animals. Their presence in water indicates fecal pollution and potentially adverse contamination by pathogens.

Conductivity. A measure of the ability of a solution to carry an electrical current.

Designated uses. Those water uses identified in state water quality standards that must be achieved and maintained as required under the Clean Water Act. Uses can include cold water fisheries, public water supply, and irrigation.

Dissolved oxygen (DO): The oxygen freely available in water, vital to fish and other aquatic life and for the prevention of odors. DO levels are considered a most important indicator of a water body's ability to support desirable aquatic life. Secondary and advanced waste treatment plants are generally designed to ensure adequate DO in waste-receiving waters.

Ecosystem. The interacting system of a biological community and its non-living environmental surroundings.

Erosion. The wearing away of land surface by wind or water, intensified by land-clearing practices related to farming, residential or industrial development, road building, or logging.

Eutrophication. The slow aging process during which a lake, estuary, or bay evolves into a bog or marsh and eventually disappears. During the later stages of eutrophication the water body is choked by abundant plant life due to higher levels of nutritive compounds such as nitrogen and phosphorus. Human activities can accelerate the process.

Fertilizer. Natural (manure) or man-made (urea) substance used to make the soil more fertile and promote plant growth.

Fossil fuel. Fuel derived from ancient organic remains (peat, coal, crude oil, and natural gas).

Groundwater. The supply of fresh water found beneath the Earth's surface, usually in aquifers, which supply wells and springs. Because ground water is a major source of drinking water, there is growing concern over contamination from leaching agricultural or industrial pollutants or leaking underground storage tanks.

Habitat. The place where a population (human, animal, plant, microorganism) lives and its surroundings, both living and non-living.

Indicator. 1. In biology, any biological entity or processes or community whose characteristics show the presence of specific environmental conditions. 2. In chemistry, a substance that shows a visible change, usually of color, at a desired point in a chemical reaction. 3. A device that indicates the result of a measurement (a pressure gauge or a moveable scale).

Nitrate. A compound containing nitrogen that can exist in the atmosphere or as a dissolved gas in water and which can have harmful effects on humans and animals. Nitrates in water can cause severe illness in infants and domestic animals. A plant nutrient and inorganic fertilizer, nitrate is found in septic systems, animal feed lots, agricultural fertilizers, manure, industrial waste waters, sanitary landfills, and garbage dumps.

Nutrient. Any substance assimilated by living things that promotes growth. The term is generally applied to nitrogen and phosphorus in wastewater but is also applied to other essential and trace elements.

Nutrient pollution. Contamination of water resources by excessive inputs of nutrients. In surface waters, excess algal production is a major concern.

Nonpoint sources. Diffuse pollution sources (those without a single point of origin or not introduced into a receiving stream from a specific outlet). The pollutants are generally carried off the land by storm water. Common nonpoint sources are agriculture, forestry, urban, mining, construction, dams, channels, land disposal, saltwater intrusion, and city streets.

Organism. Any form of animal or plant life.

Pesticide. Substances or mixture thereof intended for preventing, destroying, repelling, or mitigating any pest. Also, any substance or mixture intended for use as a plant regulator, defoliant, or desiccant.

Parameter. A variable, measurable property whose value is a determinant of the characteristics of a system. (Temperature, pressure, and density are parameters of the atmosphere.)

pH. An expression of the intensity of the basic or acid condition of a liquid; may range from 0 to 14, where 0 is the most acid and 7 is neutral. Natural waters usually have a pH between 6.5 and 8.5.

Phosphates. Certain chemical compounds containing phosphorus.

Phosphorus. An essential chemical food element that can contribute to the eutrophication of lakes and other water bodies. Increased phosphorus levels result from discharge of phosphorus-containing materials into surface waters.

Photosynthesis. The manufacture by plants of carbohydrates and oxygen from carbon dioxide mediated by chlorophyll in the presence of sunlight.

Phytoplankton. That portion of the plankton community comprised of tiny plants (algae, diatoms).

Point source. A stationary location or fixed facility from which pollutants are discharged; any single identifiable source of pollution (pipe, ditch, ship, ore pit, factory smokestack).

Pollutant. Any substance introduced into the environment that adversely affects the usefulness of a resource or the health of humans, animals, or ecosystems.

Pollution. The presence of a substance in the environment that because of its chemical composition or quantity prevents the functioning of natural processes and produces undesirable environmental and health effects. Under the Clean Water Act, for example, the term has been defined as the man-made or man-induced alteration of the physical, biological, chemical, and radiological integrity of water and other media.

Runoff. That part of precipitation, snow melt, or irrigation water that runs off the land into streams or other surface-water. It can carry pollutants from the air and land into receiving waters.

Secchi disk. Black and white disk used to measure the turbidity of a water body.

Sediment. Topsoil, sand, and minerals washed from the land into water, usually after rain or snow melt.

Septic system: An on-site system designed to treat and dispose of domestic sewage. A typical septic system consists of a tank that receives waste from a residence or business and a system of tile lines or a pit for disposal of the liquid effluent (sludge) that remains after decomposition of the solids by bacteria in the tank and must be pumped out periodically.

Septic tank. An underground storage tank for wastes from homes not connected to a sewer line. Waste goes directly from the home to the tank.

Sewage. The waste and wastewater produced by residential and commercial sources and discharged into sewers.

Sewer. A channel or conduit that carries wastewater and stormwater runoff from the source to a treatment plant or receiving stream. "Sanitary" sewers carry household, industrial, and commercial waste. "Storm" sewers carry runoff from rain or snow. "Combined" sewers handle both.

Silt. Sedimentary materials composed of fine or intermediate-sized mineral particles.

Storm sewer. A system of pipes (separate from sanitary sewers) that carries water runoff from buildings and land surfaces.

Stressors. Physical, chemical, or biological entities that can induce adverse effects on ecosystems or human health.

Temperature. hotness or coldness of a substance.

Total dissolved solids (TDS). All material that passes the standard glass river filter; now called total filterable residue. Term is used to reflect salinity.

Turbidity. A cloudy condition in water due to suspended silt or organic matter.

Water quality. The chemical, physical, and biological condition of a body of water.

Water quality criteria. Levels of water quality expected to render a body of water suitable for its designated use. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes.

Water quality standards: State-adopted and EPA-approved ambient standards for water bodies. The standards prescribe the use of the water body and establish the water quality criteria that must be met to protect designated uses.

Watershed. The land area that drains into a stream; the watershed for a major river may encompass a number of smaller watersheds that ultimately combine at a common point.

Zooplankton. Small (often microscopic) free-floating aquatic plants or animals.

National Education Standards

1. The Nature of Science

A. The Scientific World View

The results of similar scientific investigations seldom turn out exactly the same. Sometimes this is because of unexpected differences in the things being investigated, sometimes because of unrealized differences in the methods used or in the circumstances in which the investigation is carried out, and sometimes just because of uncertainties in observation. It is not always easy to tell which (Grades 3-5).

B. Scientific Inquiry

Scientific investigations may take many different forms, including observing what things are like or what is happening somewhere, collecting specimens for analysis, and doing experiments. Investigations can focus on physical, biological and social questions (Grades 3-5).

Results of scientific investigations are seldom exactly the same, but if the differences are large, it is important to try to figure out why. One reason for following directions carefully and for keeping records of one's work is to provide information on what might have caused the differences (Grades 3-5).

C. The Scientific Enterprise

Clear communication is an essential part of doing science. It enables scientist to inform others about their work, expose their ideas to criticism by other scientists, and stay informed about scientific discoveries around the world (Grades 3-5).

Accurate record-keeping, openness, and replication are essential for maintaining an investigator's credibility with other scientists and society (Grades 6-8).

3. The Nature of Technology

A. Technology and Science

Technology enables scientists and other to observe things that are too small or too far away to be seen without them and to study the motion of objects that are moving very rapidly or are hardly moving at all (Grades 3-5).

Technology is essential to science for such purposes as access to outer space and other remote locations, sample collection and treatment, measurement, data collection and storage, computation and communication of information (Grade 6-8).

4. The Physical Setting

B. The Earth

Fresh water, limited in supply, is essential for life and also for most industrial processes. Rivers, lakes, and groundwater can be depleted or polluted, becoming unavailable or unsuitable for life (Grades 6-8).

The benefits of the earth's resources—such as fresh water, air, soil, and trees—can be reduced by using them wastefully or by deliberately or inadvertently destroying them. The atmosphere and the oceans have a limited capacity to absorb wastes and recycle materials naturally. Cleaning up polluted air, water, or soil or restoring depleted soil, forests, or fishing grounds can be very difficult and costly (Grades 6-8).

C. Processes that Shape the Earth

Human activities, such as reducing the amount of forest cover, increasing the amount and variety of chemicals released into the atmosphere, and intensive farming, have changed the earth's land, oceans, and atmosphere. Some of these changes have decreased the capacity of the environment to support some life forms (Grades 6-8).

5. The Living Environment

A. Diversity of Life

A great variety of kinds of living things can be sorted into groups in many ways using various features to decide which things belong to which group (Grades 3-5).

Features used for grouping depend on the purpose of the grouping (Grades 3-5).

Interdependence of Life: For any particular environment, some kinds of plants and animals survive well, some survive less well, and some cannot survive at all (Grades 3-5).

Changes in an organism's habitat are sometimes beneficial to it and sometimes harmful (Grades 3-5).

D. Interdependence of Life

In all environments—freshwater, marine, forest, desert, grassland, mountain, and others—organisms with similar needs may compete with one another for resources, including food, space, water, air, and shelter. In any particular environment, the growth and survival of organisms depends on the physical conditions (Grades 6-8).

F. Evolution of Life

Individual organisms with certain traits are more likely to survive and have offspring. Changes in environmental conditions can affect the survival of individual organisms and entire species (Grades 6-8).

9. The Mathematical World

D. Uncertainty

The larger a well-chosen sample is, the more accurately it is likely to represent the whole. But there are many ways of choosing a sample that can make it unrepresentative of the whole (Grades 6-8).

11. Common Themes

A. Systems

In something that consists of many parts, the parts usually influence one another (Grades 3-5).

Thinking about things as systems means looking for how every part relates to others. The output from one part of a system (which can include material, energy, or information) can become the input to other parts. Such feedback can serve to control what goes on in the system as a whole (Grades 6-8).

Any system is usually connected to other systems both internally and externally. Thus a system may be thought of as containing subsystems and as being a subsystem of a larger system (Grades 6-8).

C. Constancy and Change

Physical and biological systems tend to change until they become stable and then remain that way unless their surroundings change (Grades 6-8).

12. Habits of Mind

A. Values and Attitudes

Keep records of their investigations and observations and not change the records later (Grades 3-5).

Offer reasons for their findings and consider reasons suggested by others (Grades 3-5).

Know why it is important in science to keep honest, clear, and accurate records (Grades 6-8).

Source: American Association for the Advancement of Science, *Benchmarks for Science Literacy,* 1993.

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