AEN-178

Cooperative Extension Service

Wetland Curriculum for Kentucky High Schools

Emily Nottingham, Tiffany Messer, and Carmen Agouridis, Biosystems and Agricultural Engineering

Table of Contents

Wetland Educational Needs in High Schools

Wetland curriculum for high schoolers is designed to provide students with knowledge concerning the natural environment and its associated problems with water quality and quantity, along with awareness of how to help solve these problems. The wetland curriculum introduces water quality concerns in surface and groundwater from humans (e.g., urbanization, mining activities, agricultural practices) and environmental factors (e.g., flood events, droughts). It also includes learning about wetland processes (e.g., nitrogen cycle, water cycle, phytoremediation, sorption, nutrient mixing, microbial activity) and functions (e.g., water storage, water treatment, animal and pollinator habitat, flood control, recreation). Implementation of the wetland curriculum into science classes allows students to make connections between restoration, environmental policies and regulations, and the engineering design process.

Kentucky Academic Science Standards focus on providing a high-quality standard educational curriculum to all students attending public high schools in the Commonwealth (KDE, 2015). The Career and Technical Education (CTE) Academic and Employability Pathway Standards, also developed by the Kentucky Department of Education, aim to prepare students for high-demand jobs in the 21st century global economy. The following wetland educational curriculum falls under the goals of the Kentucky Education Reform Act of 1990 by helping to fulfill "sufficient preparation to choose and pursue their life's work intelligently." This important goal is met when students are presented with the knowledge and skills to be able to pursue careers in science, technology, engineering, and mathematics (STEM), including careers in ecological restoration, water resources engineering, water treatment, and environmental policy. Furthermore, the wetland curriculum meets the following requirements:

1. Use basic communication and mathematics skills for purposes and situations they will encounter throughout their lives.
2. Apply core concepts and principles from mathematics, science, arts, and humanities to situations they will encounter throughout their lives.
3. Connect and integrate experiences and new knowledge from all subject matter fields with what students have previously learned and build on past learning experiences to acquire new information through various media sources.

The wetland curriculum integrates the following science and engineering outcomes created by the Kentucky Department of Education: (1) Matter and Energy in Organisms and Ecosystems; (2) Interdependent Relationships in Ecosystems; (3) Human Sustainability; and (4) Engineering Design. The wetland curriculum also integrates the following CTE standards: (1) Speaking and Listening; (2) Reading and Writing; (3) Critical Thinking and Problem Solving; (4) Mathematics; (5) Information Technology; (6) Time, Task and Resource Management; (7) Teamwork; (8) Creativity and Resourcefulness; (9) Job Acquisition and Advancement; (10) Job Specific Technologies; and (11) Health and Safety.

The Kentucky Department of Education High School Science Standards and the Career and Technical Education (CTE) Academic and Employability Pathway Standards included in the Wetland Curriculum for Kentucky High Schools (KDE, 2022).

	Standard	Standard Number	Text
Kentucky Academic High School Standards	Matter and Energy in Organisms and Ecosystems	HS-LS2-3	Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.
		HS-LS2-4	Use a mathematical representation to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
	Human Sustainability	HS-ESS3-1	Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and climate changes have influenced human activity.
		HS-ESS3-3	Create a computation simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity.
		HS-ESS3-4	Evaluate or refine a technological solution that reduces the impacts of human activities on natural systems.
		HS-ESS3-6	Use a computation representation to illustrate the relationship among Earth systems and how those relationships are being modified due to human activity.

	Standard	Standard Number	Text
Kentucky Academic High School Standards	Interdependent Relationships in Ecosystems	HS-LS2-1	Use mathematical and/or computational representations to support explanations of factors that affect the carrying capacity of ecosystems at different scales.
		HS-LS2-2	Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
		HS-LS2-7	Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
		HS-LS4-6	Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.
	Engineering Design	HS-ETS1-1	Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
		HS-ETS1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
		HS-ETS1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
Career and Technical Education (CTE) Academic and Employability Pathway Standards	Speaking and Listening	AA1	Utilize effective verbal and nonverbal communication skills.
		AA2	Participate in conversation, discussion, and group presentations.
		AA3	Communicate and follow directions/procedures.
		AA4	Utilize speaking and listening skills to communicate effectively with customers and co-workers.
	Reading and Writing	AB1	Locate and interpret written information.
		AB2	Read and interpret workplace documents, e.g., reports, manuals, schematics, flowcharts, tables, and graphs.
		AB3	Identify relevant details, facts, and specifications.
		AB4	Record information accurately and completely.
		AB5	Demonstrate competence in organizing, writing, and editing using correct vocabulary, spelling, grammar, and punctuation.
		AB6	Demonstrate the ability to write clearly and concisely using industry-specific terminology.
	Critical Thinking and Problem Solving	AC1	Utilize critical-thinking skills to determine the best options/outcomes, e.g., analyze reliable/unreliable sources of information, use previous experiences, implement crisis management, and develop contingency planning.
		AC2	Utilize innovation and problem-solving skills to arrive at the best solution for the current situation.
		AC3	Implement effective decision-making skills.

	Standard	Standard Number	Text
Career and Technical Education (CTE) Academic and Employability Pathway Standards	Mathematics	AD1	Perform basic and higher-level math operations, e.g., addition, subtraction, multiplication, division, decimals, fractions, units of conversion, averaging, percentage, proportion, ratios, and numbering systems.
		AD2	Solve problems using measurement skills, e.g., distance, weight, area, and volume.
		AD3	Make reasonable estimates.
		AD4	Use tables, graphs, diagrams, and charts to obtain or convey information.
		AD5	Use reasoning and problem-solving skills in mathematics.
	Information Technology	AG1	Use technology appropriately to enhance professional presentations.
	Time, Task, and Resource Management	ED1	Plan and follow a work schedule.
		ED2	Complete work tasks successfully with minimal supervision.
		ED4	Demonstrate ability to stay on task to produce high-quality deliverables on time.
	Teamwork	EF1	Recognize the characteristics of a team environment and a conventional workplace.
		EF2	Demonstrate effective team skills, e.g., setting goals, listening, following directions, questioning, dividing work, conflict resolution, meeting facilitation, and evaluating their importance in the workplace.
	Creativity and Resourcefulness	EG1	Explain the importance of contributing and conveying new ideas in the workplace.
		EG2	Describe the importance of posing questions when developing ideas.
		EG3	Explain the value of varying ideas and opinions.
		EG4	Locate and verify information during the creative process.
	Job Acquisition and Advancement	EK2	Define jobs associated with a specific career path or profession.
	Job-Specific Technologies	EM1	Identify the value of new technologies and their impact on driving continuous change and the need for lifelong learning.
		EM2	Research and identify emerging technologies for specific careers.
		EM3	Select appropriate technological resources to accomplish work.
	Health and Safety	EN1	Identify and assume responsibility for the safety of self and others.
		EN2	Follow safety guidelines in the workplace, e.g., OSHA, CDC.

Additional Resources

Kentucky Department of Education (2022). Kentucky Academic Standards. Retrieved by https://www.education.ky.gov/curriculum/standards/kyacadstand/Documents/Kentucky_Academic_Standards_for_Science_2022.pdf

Lesson Plan 1: Metaphors for Wetland Functions and Importance

This lesson is an exploratory wetlands game where the students learn about the functions of wetlands and their importance to the environment. To begin, ask the students to research wetlands with three goals in mind: (1) be able to define what a wetland is, (2) explain the different components (e.g., soils, plants, hydrology) of a wetland, and (3) come up with several benefits that wetlands provide the environment and the community. Following this, the class can be split into groups of three to five. Each group is given a wetland container (i.e., a box) from which the students pull common household items blindly. In their groups, the students can come up with answers to explain what each item in the container represents in a wetland. A class discussion at the end of the activity should review the connections between each object in the container compared to wetlands in nature. The total time for the lesson is approximately 45 minutes. This lesson was adapted from Project WILD (1992). This lesson plan is designed for grades 9-12.

Learning Objectives

1. Describe the characteristics of wetlands.
2. Appreciate the importance of wetlands to wildlife and humans.
3. Identify the ecological functions of wetlands and why they are important to the environment.

Materials Needed (Per Group)

- Container
- Sponge
- Whisk
- Toy boat
- Strainer
- Coffee filter
- Antacid
- Baggie of rice
- Picture of hotel/house
- First aid kit
- Pipe fitting

Procedures

1. Build the wetlands by placing one of each object into the container.
2. Divide the class into groups of three to five students and place a wetland container in front of each group.
3. Instruct the groups to pull out the objects and discuss among themselves what each object represents as a wetland function.
4. Bring the class back together and ask each of the groups to tell the class what they think each object represents and why.
5. After each group has discussed, tell the class the correct answers and discuss the reasons why (Table 1).

Focus Questions

1. What are some of the main functions or benefits of wetlands?
2. Based on your research, what additional wetland components or benefits are missing from the wetland container?
3. What are things that we can do as citizens to protect wetlands?

Table 1. Wetland container objects and their corresponding metaphors for wetland functions.

Object	Wetland function
Sponge	Absorbs excess water caused by runoff; retains moisture for a time even if standing water dries up (e.g., sponge stays wet even after it has absorbed a spill)
Whisk	Mixes nutrients and oxygen into the water
Strainer	Provides erosion control by straining silt and debris from water
Coffee filter	Filters smaller impurities from water (excess nutrients and toxins)
Antacid	Neutralizes toxic substances
Pipe fitting	Supplies water to underground water sources
Picture of house/hotel	Habitat for diverse wildlife
Baggie of rice	Provides nutrient-rich food for wildlife and humans
First aid kit	Medicines have been developed from discoveries made in wetlands. For example, the willow tree is a source of salicylic acid used in pain medicine and skin treatment
Toy boat	Provides a source of recreation for humans

Additional Resources

Association of Fish and Wildlife Agencies (2022). Aquatic WILD K-12 Guide. https://www.fishwildlife.org/projectwild/aquatic-wild

Nottingham, E. R., Gumbert, A., Messer, T. L. (2024). Understanding and Protecting Kentucky Wetlands. ID-279. https://www2.ca.uky.edu/agcomm/pubs/ID/ID279/ID279.pdf

Project WILD (1992). Wetland metaphors. Council for Environmental Education. Retrieved by https://migration.fsnaturelive.org/pdf/Wetland_Metaphors.pdf

Lesson Plan 2: Heads-up for Wetlands

Heads-up for Wetlands is an introductory game about natural and constructed wetlands to learn about their functions, design, and monitoring. Students should research wetlands using the terms in the deck of cards as a guide. Divide students into groups of four, in which each group has two paired teams that will take turns. One student should wear a headpiece and clip a random card from the deck onto it, facing outward, without looking at the picture. The student's partner is tasked with describing the picture until the student wearing the card correctly guesses what the picture is. This is a timed game; each pair has two minutes to identify as many cards as possible correctly. The game ends when all the cards in the deck have been awarded. The approximate time to complete the lesson is 50 minutes. This lesson plan is designed for grades 9-12.

Learning Objectives

1. Learn key terms for functions, designs, and benefits of wetlands.
2. Identify common natural and constructed wetlands in Kentucky.

Materials Needed

– A deck of heads-up cards for every four students (Appendix A)
– A headpiece for each student in the class, constructed using a strip of paper with one end stapled to the other to form a circle and an attached paper clip (Figure 1)
– A two-minute timer for every four students

Procedures

1. Divide the class into groups of four and ask each student to pick a team partner in their group.
2. Provide each group with a deck of wetland cards and four headpieces.
3. Have each group place the deck of cards facing down in the middle of the table.
4. Instruct one student in each group to put on a headpiece and clip a wetland card from the deck onto it, facing outward, without looking at the card. At the same time, another person in the group starts the timer.
5. The partner of the person with the card displayed on the headpiece will begin describing the picture. The person describing the picture is not allowed to say the word(s) written on the card or rhyme with the word. Acting it out is allowed.
6. If the person with the card guesses the picture correctly, the card is awarded to the team, another card is selected from the deck and clipped to the headpiece, and the turn continues.
7. Skipping cards is allowed, but the person must place the skipped card back into the middle of the deck to be used again.
8. Each pair will have two minutes to identify as many cards correctly as they can.
9. The rounds will continue until all cards in the deck have been awarded. The team with the most cards wins.

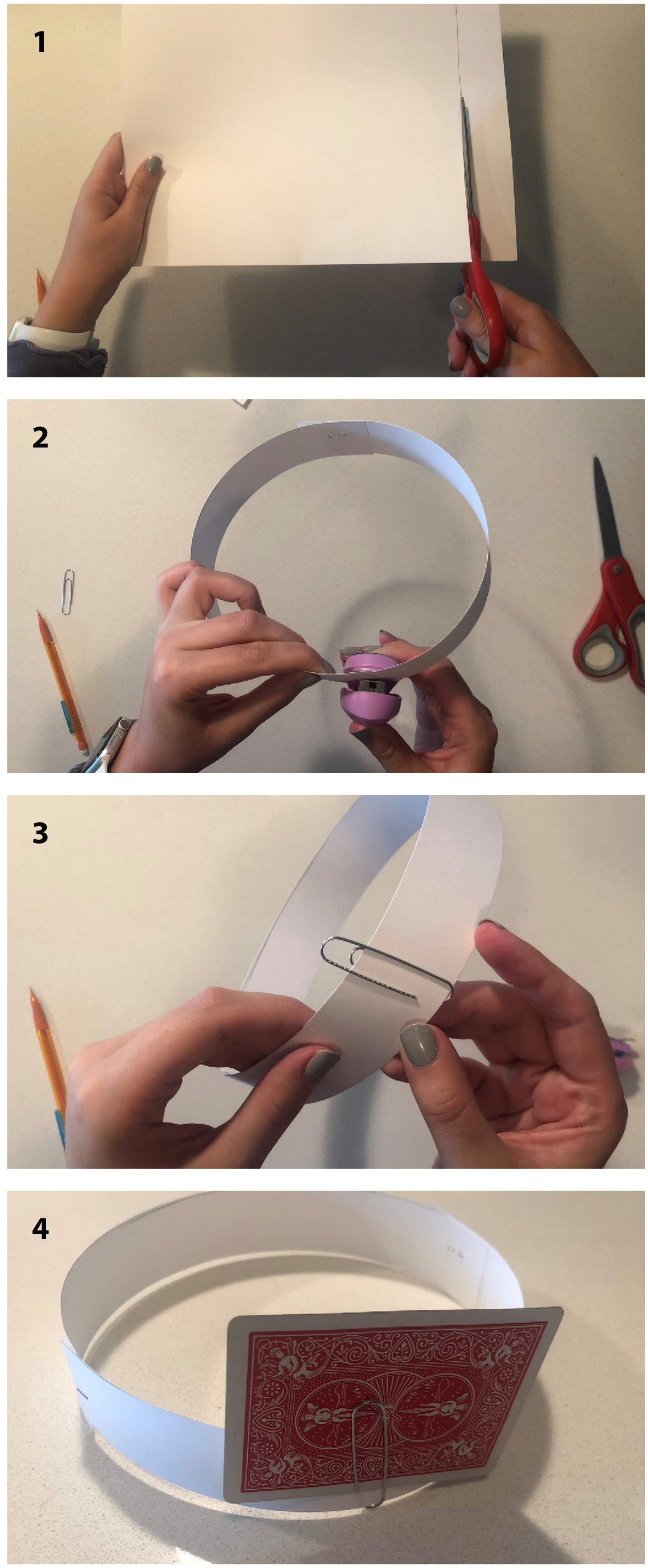


Figure 1. A diagram of how to make a headpiece for the Heads-up for Wetlands game.

Wetland Terms and Definitions

Anaerobic: An environment that is free of oxygen. The term is often used to describe wetland soil that is completely saturated with water. Anaerobic soil conditions are important for nitrogen removal (e.g., denitrification).

Bottom-land hardwood forest: The most common type of wetland found in Kentucky, consisting of deciduous and evergreen forests located in low-lying areas adjacent to rivers and streams.

Constructed wetlands: Treatment systems that use natural processes involving vegetation (plant uptake), soils (sorption), and microbes (denitrification) to improve water quality.

Denitrification: A microbial process in which microbes transform nitrate-nitrogen into nitrogen gas that is released into the atmosphere. This results in permanently removing nitrate-nitrogen from the water.

Dissolved oxygen: The dissolution of oxygen into water. It is highly dependent upon temperature (warmer temperatures result in increased solubility of oxygen in water). Since oxygen is consumed in the breakdown of organic pollutants, dissolved oxygen can give a rapid assessment of the level of pollution in a river.

Erosion and sediment control: Wetlands reduce the amount of soil particles that are carried off land and into surface waters, due to vegetation trapping and slowing of the flow of water across the land.

Floating treatment wetland: Also referred to as floating wetland islands or artificial reed beds, it consists of wetland plants growing on a floating mat on the lake water surface, in contrast to being planted in soil like traditional wetlands.

Freshwater emergent wetlands: Wetlands that are dominated by soft-stemmed vegetation such as grasses, sedges, and rushes.

Flood control: Wetlands can function as a natural sponge that traps and slowly releases water. Trees and other wetland plants also slow the speed of floodwaters, limiting the harmful impact of storm events.

Horizontal flow constructed wetlands: Type of constructed wetland where vegetation is planted in the soil and water is routed from one side, flowing horizontally through the wetland until it reaches the outlet on the opposite side.

Hydrophytes: Wetland plants can be referred to as hydrophytes or emergent vegetation, meaning that the plants grow in or on water. Common wetland plants include cattails, arrowheads, water lilies, and different kinds of sedges and rushes.

Microbes: Microorganisms (bacteria) that are important for contaminant treatment and transformation within wetlands.

Nitrogen: A common nutrient found in surface and groundwater. Different species of nitrogen exist in the environment including nitrate (NO_3^-), ammonia (NH_3), ammonium (NH_4^+), and nitrite (NO_2^-). Fertilizers used in agriculture, lawn care, and gardens and human and animal waste are common sources of excess nitrogen in the environment.

Nitrification: The nitrification process requires two distinct microbial groups to convert ammonia to nitrites (*Nitrosomonas*, *Nitrosospira*, *Nitrosococcus*, and *Nitrosolobus*) and then convert nitrites to nitrates (*Nitrobacter*, *Nitrospina*, and *Nitrococcus*).

Organic carbon: Enters the soil through decomposition of plants, animals, roots, microorganisms, and soil biota. Organic carbon is the energy source microbes use for denitrification.

pH: Measures how acidic or alkaline a substance is and ranges on a scale from 0 to 14, with a pH of 7 indicating neutral conditions. A wetland's pH typically ranges from 6.5 to 9, with a pH of 7 ideal for denitrification to occur.

Phosphate: A common nutrient found in surface and groundwater. Phosphate can result from natural occurrences in soils and rocks (e.g., limestone) as well as human activities from fertilizer and pesticide (e.g., glyphosate) applications.

Plant uptake: A wetland treatment process in which plants uptake contaminants into the roots, shoots, and leaves. Plant uptake temporarily removes nitrate-nitrogen by taking it up and holding it in the plant tissue throughout the growing season, then releasing nitrate-nitrogen back into the water as the plants die in the fall.

Recreation: Wetlands can provide recreational activities, including hiking, boating, hunting, fishing, and birdwatching.

Swamps: Any wetland that is dominated by woody plants. Swamps can be defined as either forested or shrub swamps and can be home to a variety of species, such as wood ducks, cottonmouth snakes, river otters, and many types of amphibians.

Sorption: The physical and chemical process by which one substance becomes attached to another.

Turbidity: The degree to which turbulent flow maintains suspended sediment in the water, giving the water an opaque appearance.

Vernal pools: Seasonal depressional wetlands that may be covered in shallow water during winter and spring but completely dry during the summer and fall. These types of wetlands are home to shrubs and grasses that spend the dry season as seeds and then grow and reproduce during the wet season. Vernal pools are also home to rare amphibians such as wood frogs and salamanders.

Vertical flow constructed wetlands: A type of wetland system where the vegetation is planted in the soil and water is routed on top of the soil, flowing vertically down through the wetland.

Water pollution: Any contamination of water with chemicals or hazardous substances that can harm humans, plants, or animals. Potential sources of pollution include fertilizers, pesticides, improper treatment and disposal of wastewater, industrial activities, and mining.

Wet meadow: This type of wetland resembles grasslands that are typically drier than marshes and are without standing water for most of the year.

Wetland hydrology: The science of water movement including the timing and how much water stays within the wetland. Hydrology also helps to define if an area is considered a wetland where the ground is inundated or saturated by surface or groundwater at a frequency and duration sufficient to support wetland ecology.

Wildlife habitat: Wetlands provide habitat for many amphibians, reptiles, birds, and mammals as well as food and shelter for wildlife like deer, elk, and bears.

Focus Questions

1. What are the key components that define a wetland?
2. What is the difference between a natural wetland and a constructed wetland, and can you provide a few examples of each?
3. Can you list some important water quality characteristics that we can test for?

Lesson Plan 3: Wetland Water Quality and Testing

This lesson is divided into two phases: (1) Can You See Water Pollution Activity? and (2) Water Quality Testing of Various Liquids. This lesson was adapted from Wetlands Stewards Program Lesson 5 (2009). This lesson plan is designed for grades 9-12.

Learning Objectives

1. Apply chemistry concepts to water quality applications.
2. Know how different physiochemical properties affect water quality.
3. Learn how to measure the key physiochemical properties to determine the quality of water.
4. Understand the importance of being good environmental stewards.

Can You See Water Pollution Activity?

Begin the activity by having a class discussion about common water pollutants and how these pollutants may end up in surface and drinking water. Next, students pass around five clear glass jars, numbered 1 to 5. The jars contain water samples of surface water, tap water, bottled water, water with food coloring, and water with rubbing alcohol. Students use their sense of smell as well as visual assessments to determine whether they believe the water has been polluted. The students then discuss and vote on whether each glass is polluted. At the end of the activity, the water type is revealed and the students then can change their answers. Afterward, discuss the correct answers with the students (Table 2). The activity will take approximately 30 minutes to complete.

Materials Needed

- Five glass jars with lids labeled 1-5
- Tap water
- Bottled water
- Food coloring
- Rubbing alcohol
- Surface water, such as a water sample from a stream, wetland, or lake

Procedures

Fill the labeled glass jars: one with tap water, one with bottled water, one with bottled water and food coloring, one with water and rubbing alcohol, and one with surface water. Place the numbered lids on the corresponding jars, as listed in Table 2.

Pass the jars around the classroom and instruct the students to use their sense of smell and visual assessment to determine whether they think the water might be polluted.

The students should write down whether or not they think each jar is polluted and record the results.

Tell the students the type of water in each jar and then take a revote on whether or not the students think each jar is polluted.

Reveal the answers to the students on which jars are polluted (Table 2).

Focus Questions

1. Before you knew what type of water is in each jar, what were some key signs that you used to determine if the jar was polluted or not?
2. Why might tap water be polluted?
3. Even though food coloring is harmless to us, do you think that it impacts the quality of water for aquatic habitats?
4. What sort of tests should be done to determine if the surface water is polluted or not?
5. What is the governing agency that sets standards and limits for water quality in the United States?

Additional Resources

Osborne, A., Cocanougher, J., and Gumbert, A. 2013. Understanding and Protecting Kentucky's Watersheds. HENV-206. https://www2.ca.uky.edu/agcomm/pubs/HENV/HENV206/HENV206.pdf

Ilvento, T., Heaton, L., and Taraba, J. 2001. Understanding the Water System. IP-1s. https://www2.ca.uky.edu/agcomm/pubs/ip/ip1s/ip1s.pdf

Table 2. Water pollution activity answers.

ID	Type of water	Answer
1	Tap water	Typically, tap water is safe to drink because it has gone through water treatment before being distributed to households. Some people prefer to filter tap water to improve the taste or smell and remove contaminants that may have entered the water supply. If tap water comes from underground water wells, contaminants may enter the water supply through rocks or soils. Regular testing of tap water can help you determine if the water is safe for drinking.
2	Bottled water	This water is safe to drink and is likely not polluted.
3	Food coloring and water	The water looks polluted because it is discolored. Although the EPA does not categorize color as a pollutant, color can pollute water by blocking light to underwater plants and preventing photosynthesis, during which plants make oxygen critical to aquatic life.
4	Water and rubbing alcohol	This water looks clean but smells terrible. This water is polluted, even though it looks clear. This sample reminds students that their sense of smell often is very important in determining if water is polluted. Water may look clean but smell like sewage or other pollutants.
5	Surface water	This water may or may not be polluted; you cannot tell just by looking. Tests need to be done to determine if the water is safe for aquatic life and for recreational activity for humans.

Water Quality Testing of Various Liquids

In this activity, the students will conduct water quality testing on tap water and stream water (collected by the teacher and brought to school) and on samples to which pollutants have been added (fertilizers, household detergents, decomposed organic matter), as well as an "unknown" contaminated water sample. Ideally, students could collect water samples if the school has a stream on-site or within a short walk. If not, students will use samples the teacher collected the previous day. From there, the students can discuss results and brainstorm the origin of the contaminant in their water samples. This phase of the lesson will take approximately 60 minutes to complete.

Materials Needed

- A water sample from the tap
- Dishwashing detergent
- Fertilizer
- Leaf litter
- Water from a nearby river
- Sample bottles
- Tape and permanent marker for labeling
- LaMotte Earth Force Low-Cost Water Monitoring test kit: Order Code No. 3-5886 (https://lamotte.com/earth-forcer-low-cost-water-monitoring-kit-3-5886)
- Instructions (Appendix B)

Procedures

1. Create water samples by labeling sample bottles with "Clean water," "Polluted water with detergent," "Polluted water with fertilizer," "Polluted water with organic matter," and "Unknown."
2. Fill each of the sample bottles according to the corresponding label (Table 3).
3. Divide the class into groups of two to five students and give one of each sample bottle to each group.
4. Each group should also be given a test kit.
5. The students will begin by labeling all test tubes with a sample label and type of test (e.g., clean: pH, fertilizer: NO_3^-).
6. Have the students follow the printable instructions to test for pH, nitrates, phosphates, dissolved oxygen (DO), temperature, biochemical oxygen demand (BOD), and turbidity.
7. The students will repeat the tests for all water samples.

Label	Fill with
Clean water	Tap water
Polluted water with detergent	Tap water with some dishwashing detergent
Polluted water with fertilizer	Tap water with some fertilizer solution
Polluted water with organic matter	Tap water with leaf litter dissolved in
"Unknown"	River water

Focus Questions

1. Which sample bottle had the highest pH (most basic)? Which was the most acidic? Why do you think that is?
2. Which sample bottle had the highest levels of nitrate?
3. Which sample bottle had the highest levels of phosphate? Does it make sense that the same sample with high nitrate would also have high phosphate?
4. Which sample had the lowest DO? How would low DO in rivers and lakes impact aquatic life?
5. Which sample had the lowest BOD? How are DO and BOD related?
6. Which sample had the highest turbidity?
7. Based on your results, which sample is the most polluted? Most clean?
8. What do you think the unknown sample is?
9. Why is it important to test for water quality in drinking water and in surface water?

Additional Resources

Watsonville Wetlands Watch (2009). Wetlands Stewards Program Lesson 5: Wetland water testing. Retrieved by https://www.watsonvillewetlandswatch.org/wetland-stewards-middle-school-lessons-and-activities#lesson5

Lesson Plan 4: What is a Floating Treatment Wetland?

Background

The Southeast Nitrogen Problem

Nitrate-nitrogen (NO_3-N) is an inorganic form of nitrogen that is often used for plant fertilizer. While NO_3-N is very important for plant growth, overapplication has led to it being prevalent in both groundwater and surface waters in the southeast United States (including in Kentucky). Exposure, specifically drinking water with high NO_3-N, can lead to health effects (e.g., methemoglobinemia, also known as blue baby syndrome, and heart defects). High NO_3-N with phosphate-P (PO_4-P) can result in toxic algal blooms and enhanced *E. coli* growth in lakes and reservoirs.

Floating Treatment Wetlands (FTWs)

Floating Treatment Wetlands (FTWs), also referred to as floating wetland islands or artificial reed beds, consist of wetland plants (i.e., emergent macrophytes) growing on a floating mat on the water surface, in contrast to being rooted in sediment like traditional wetlands (Figure 2). Land is not required for FTW systems, which is often the limiting factor for traditional wetland treatment systems. FTWs have the potential to provide water treatment for total nitrogen (TN), ammonium-N (NH_4-N), NO_3-N, total microcystin-LR, *E. coli*, and total phosphorus (TP). **However, many questions remain about FTW systems, specifically regarding their potential use in the Southeast along with their management and design requirements.**

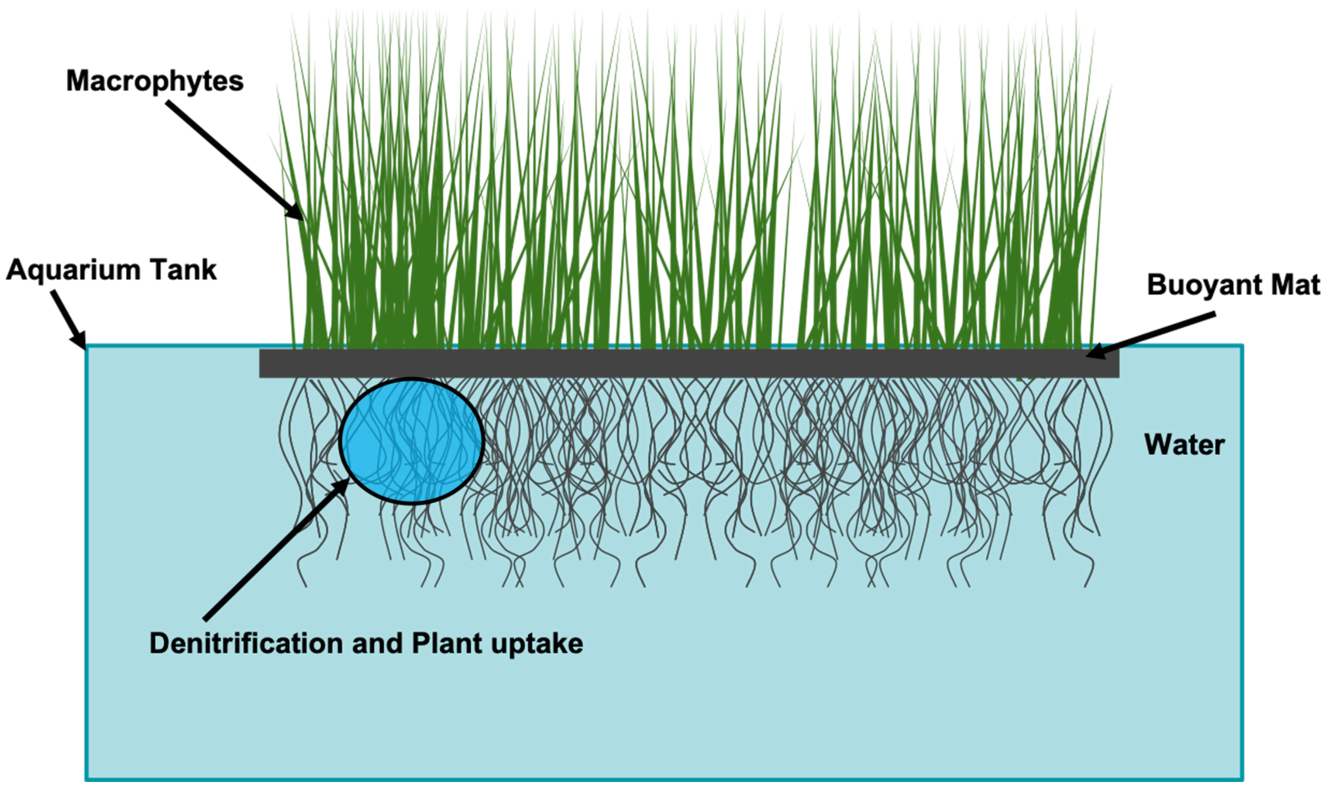


Figure 2. Floating treatment wetland (FTW) in an aquarium tank.

Denitrification versus Plant Uptake of Nitrate-N Removal

FTWs can remove NO_3-N in two primary ways: denitrification and plant uptake (Figure 3). Denitrification is a microbial process in which microbes transform NO_3-N into nitrogen gas that is released to the atmosphere. This results in **permanently** removing NO_3-N from the water. In contrast, plant uptake **temporarily** removes nitrate-N by taking up the NO_3-N, holding it in the plant tissue throughout the growing season, and then releasing NO_3-N back into the water as the plants die in the fall. This results in a **recycling** effect for the NO_3-N into and out of the water. To distinguish between the two likeliest forms of removal, water chemistry conditions can be observed. Typically, when conditions favorable for denitrification are present, denitrification will prevail over plant uptake. These conditions include:

1. pH of approximately 7
2. Dissolved oxygen less than 3 mg/L
3. Organic carbon (provided by your mat amendment or plant roots/leaves)
4. NO_3-N (provided by your fertilizer application)
5. Water temperature greater than 65° F

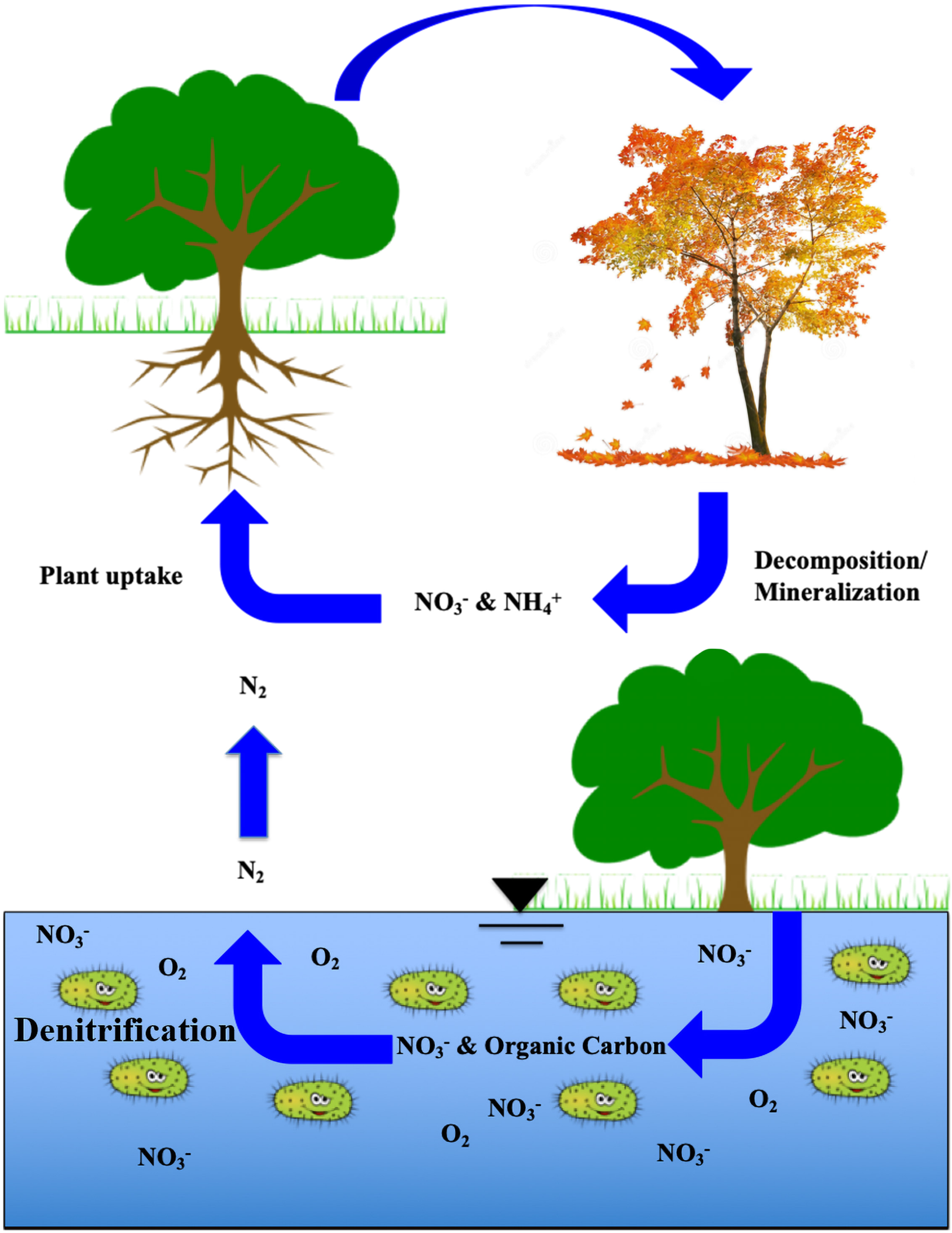


Figure 3. Nitrate-N (NO3-N) removal processes in wetlands: (top) plant uptake and (bottom) denitrification.

Learning Objective

The objective of this exercise is to study the use of FTWs for NO_3-N (a form of nitrogen fertilizer) removal to prevent algal blooms in lakes and reservoirs. Three treatments will be evaluated:

1. No FTW (control)
2. FTW
3. FTW with mat amendment

Materials Needed

- 18 aquarium tanks
- Mat (Beemats, LCC)
- Five native wetland plant plugs (e.g., milkweed, Torrey's rush, common rush, fox sedge, softstem bulrush; about $3 per plug)
- LaMotte Earth Force Low-Cost Water Monitoring test kit: Order Code No. 3-5886 (https://lamotte.com/earth-forcer-low-cost-water-monitoring-kit-3-5886)
- Fertilizer
- Mat amendments to place on top of the mat (e.g., coffee)

Procedures

1. Create a miniature floating treatment wetland (Figure 2):
   a. Add tap water to all aquariums.
   b. Leave six aquariums with just tap water.
   c. In the other aquariums, place plant plugs in floating mats and allow to establish for at least two months by providing light and fertilizing. Algae may form and can be cleaned or left.
   d. Add an amendment (e.g., coffee, straw) to the surface of six of the floating mats, while leaving the other aquariums with no amendment.
2. Add the fertilizer and mix well into all 18 of the aquariums to dissolve without disturbing the mats.
3. Over the next month, measure the NO_3-N, pH, dissolved oxygen, and temperature using the LaMotte Earth Force Low-Cost Water Monitoring test kit every week or as often as every two to three days if time allows. Do not sample on the first day, as sometimes NO_3-N needs a day or so to be mixed in. Once the NO_3-N concentrations reach 0 or 0.5 mg/L in two of the aquariums, sampling should be stopped.
4. Record values each time the samples are taken.
5. At the end of the experiment, compare the results of NO_3-N removal and changes in the water chemistry.
6. Using the following equation, determine the percentage removal for each aquarium:

$$\%_{Removal} = \frac{Nitrate_{Day1} - Nitrate_{LastDay}}{Nitrate_{Day1}}$$

$\%_{Removal}$
= percentage of NO_3-Nremoved from the aquarium
$Nitrate_{Day1}$
= concentrations of NO_3-N on Day 1 of the experiment
$Nitrate_{LastDay}$
= concentrations of NO_3-N on the last day of the experiment

Focus Questions

1. Which system removed NO_3-N the quickest? Why?
2. Which system removed the most NO_3-N? Why?
3. Were requirements for denitrification present? How did this impact removal rate and quantity?
4. How could you use these practices in your community?

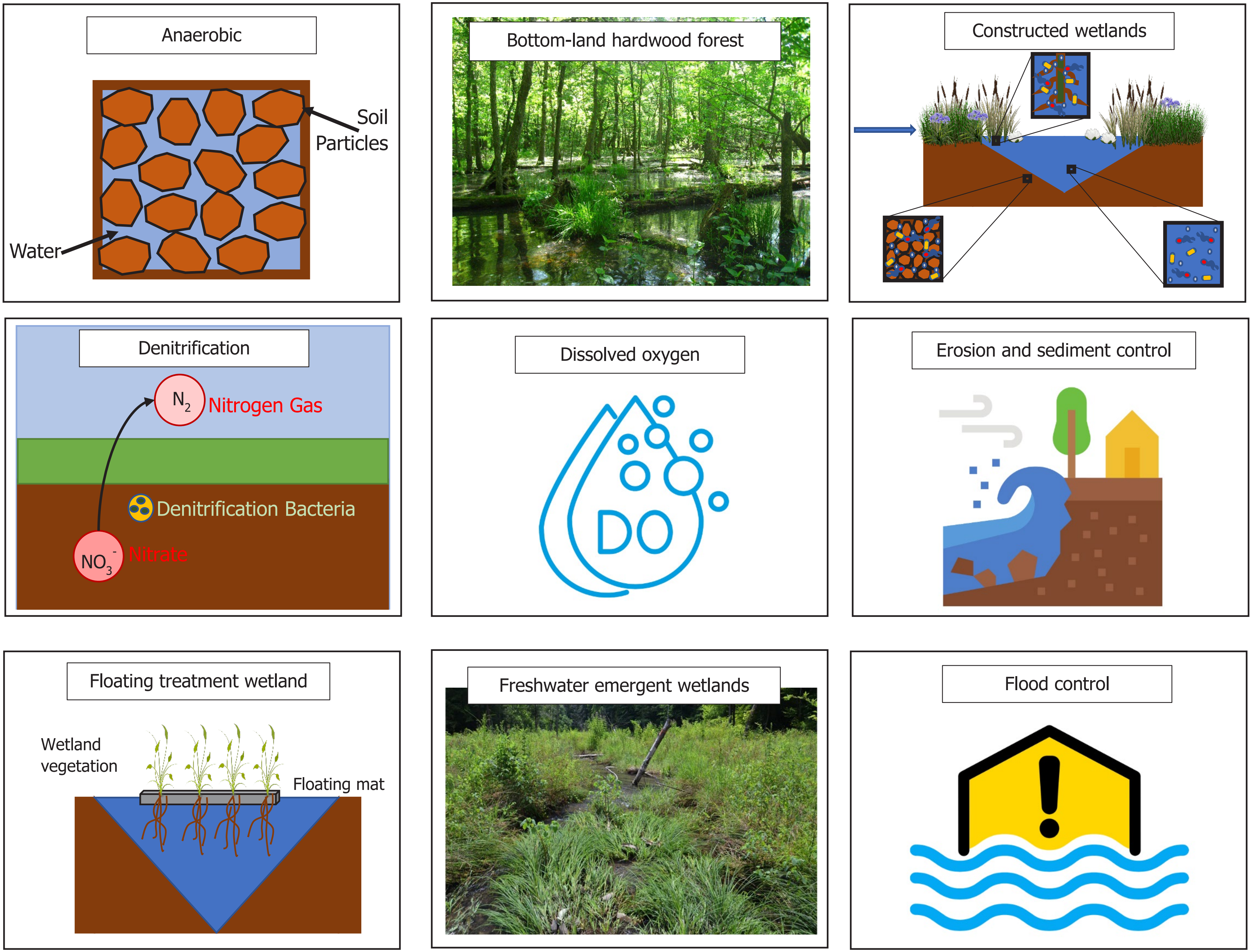
About the *meso*Wheels Program

These lessons are part of the *meso*Wheels program, which was established in 2020. The program provides a novel citizen science and education platform to improve water quality across generations and communities using treatment wetlands systems. The program aligns with Kentucky Academic Science Standards to allow educators to incorporate the program into the current curriculum. To find out more information, visit https://www.mesoprogram.com/mesoreach.

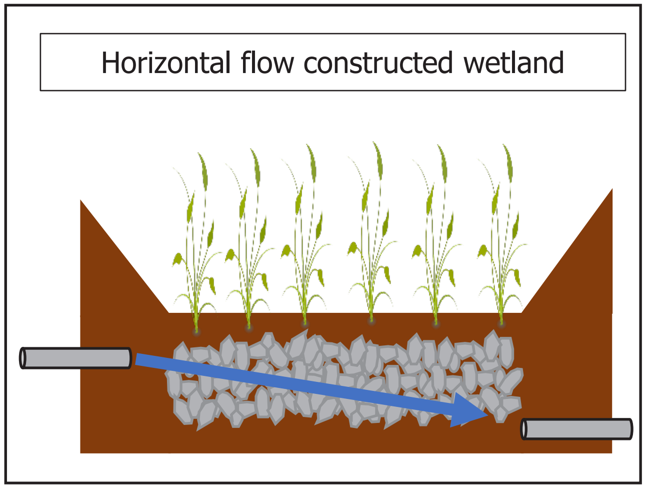
Appendix A

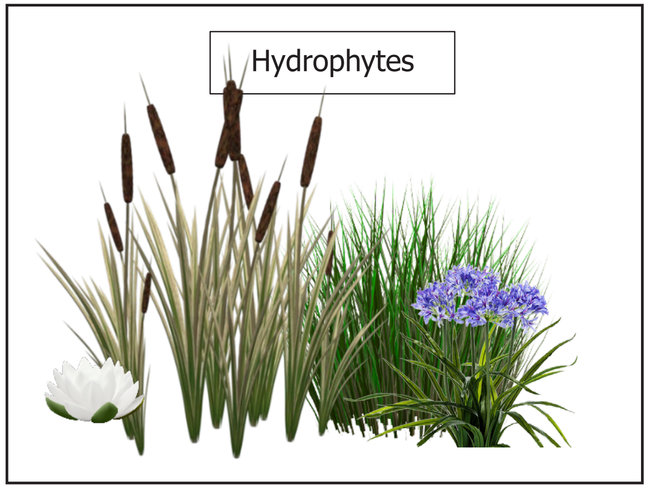
Additional Materials for Lesson Plan 2: Heads-up for Wetlands

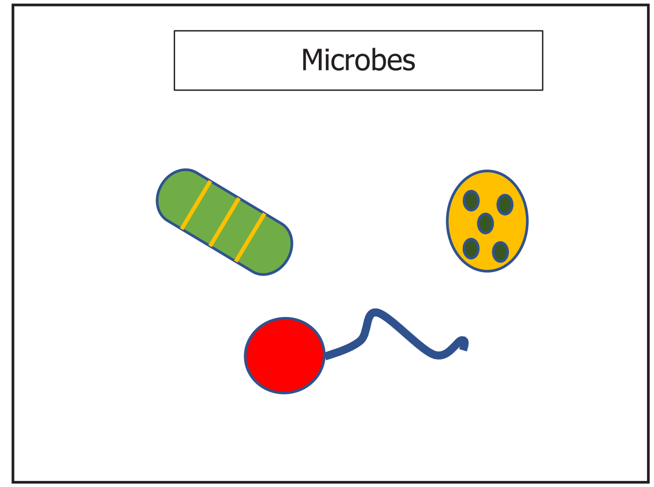
This printable deck of wetland cards can be used for the Heads-up for Wetlands game.

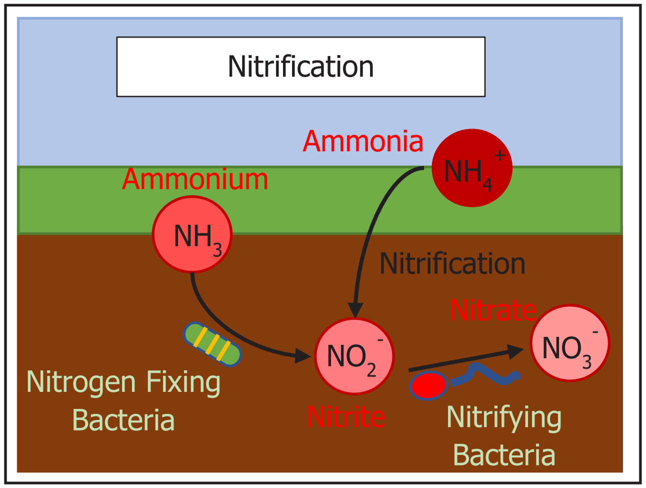


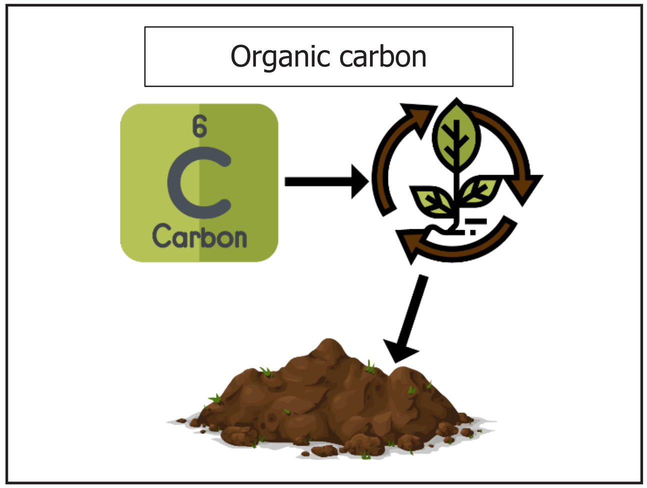
Anaerobic
Soil Particles
Water
Bottom-land hardwood forest
Constructed wetlands
Denitrification
N_2 Nitrogen Gas
Denitrification Bacteria
NO_3^- Nitrate
Dissolved oxygen
DO
Erosion and sediment control
Floating treatment wetland
Wetland vegetation
Floating mat
Freshwater emergent wetlands
Flood control

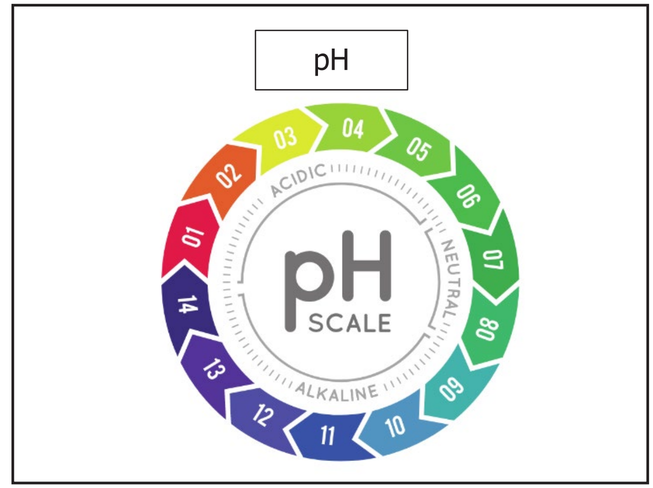

Horizontal flow constructed wetland

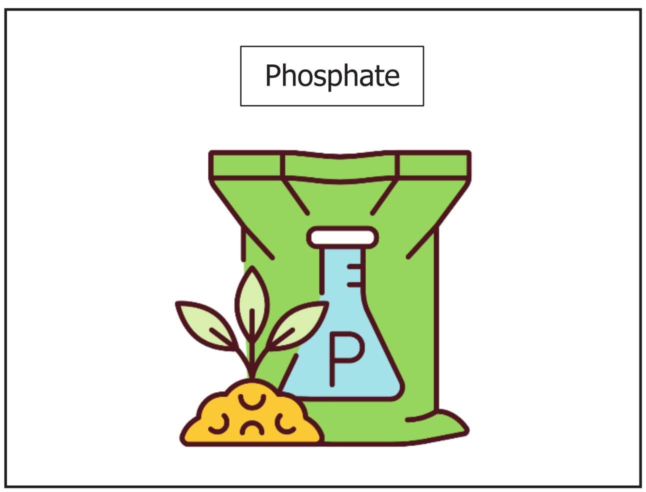

Hydrophytes

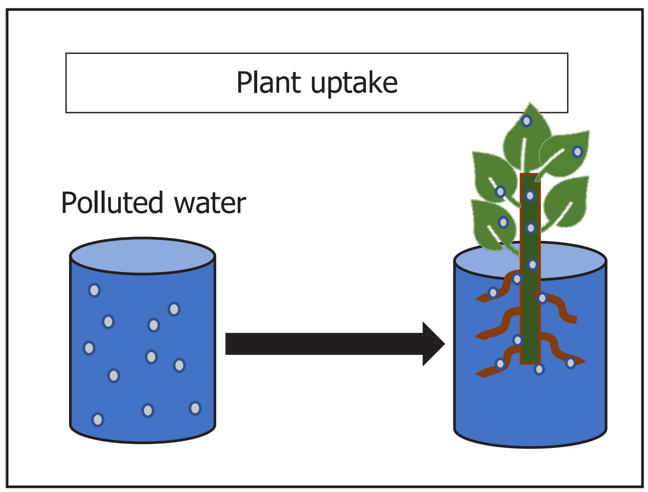

Microbes

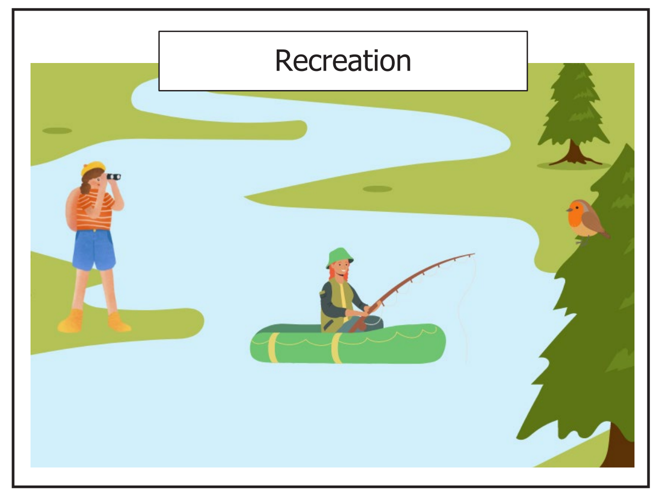

Nitrification
Ammonia
NH_4^+
Ammonium
NH_3
Nitrification
Nitrate
NO_2^-
NO_3^-
Nitrogen Fixing Bacteria
Nitrite
Nitrifying Bacteria

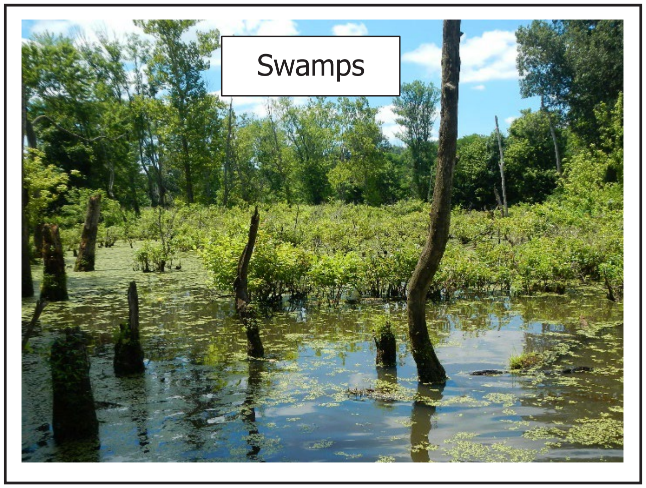

Organic carbon
6
C
Carbon

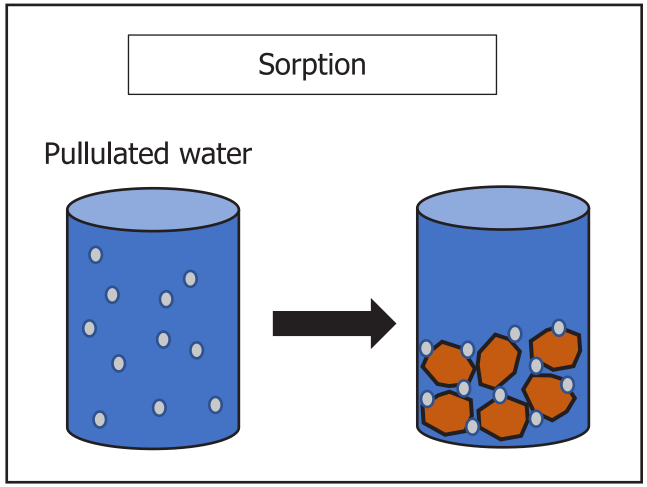

pH
pH
SCALE
ACIDIC
NEUTRAL
ALKALINE
01
02
03
04
05
06
07
08
09
10
11
12
13
14

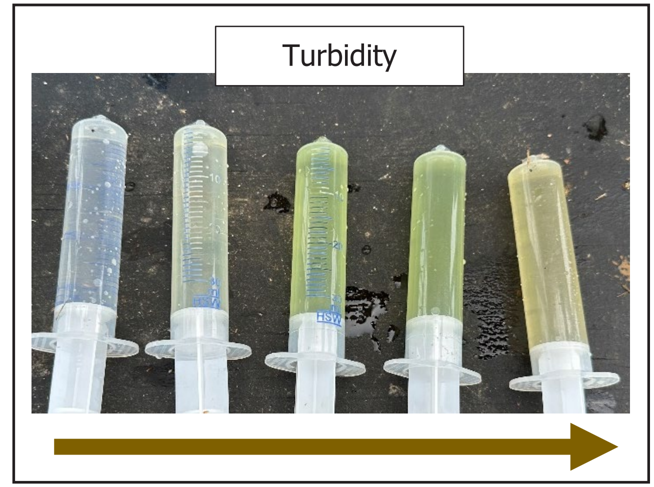

Phosphate
P

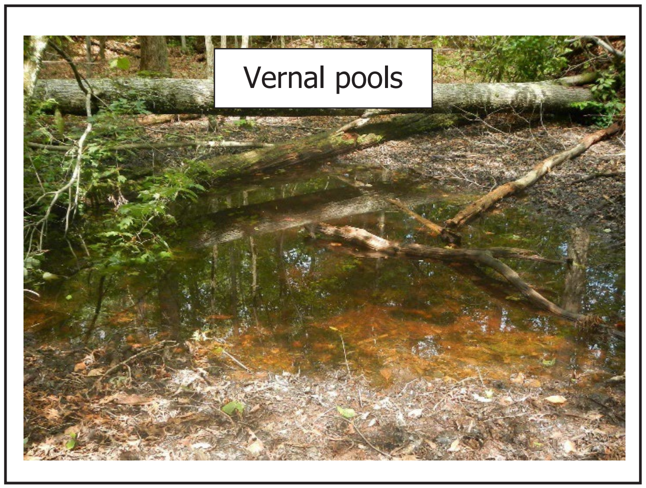

Plant uptake
Polluted water

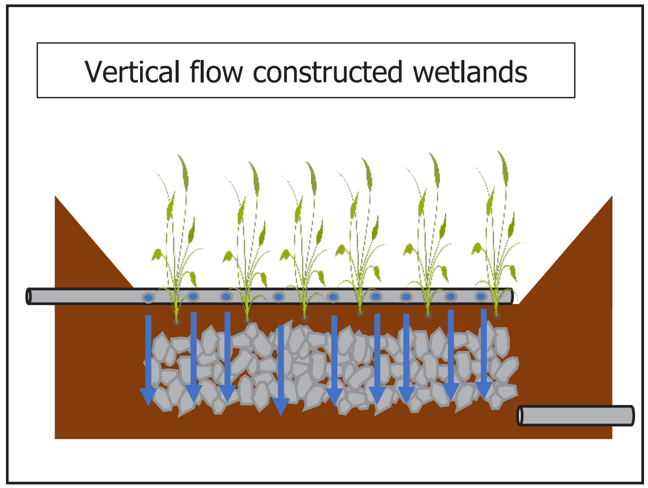

Recreation

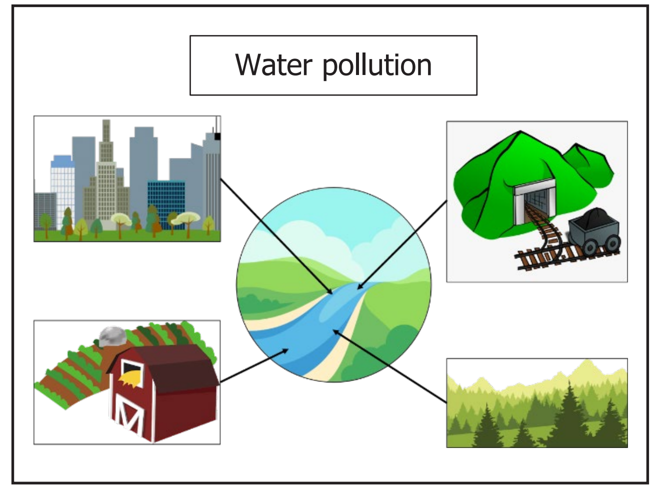

Swamps


Sorption
Pullulated water

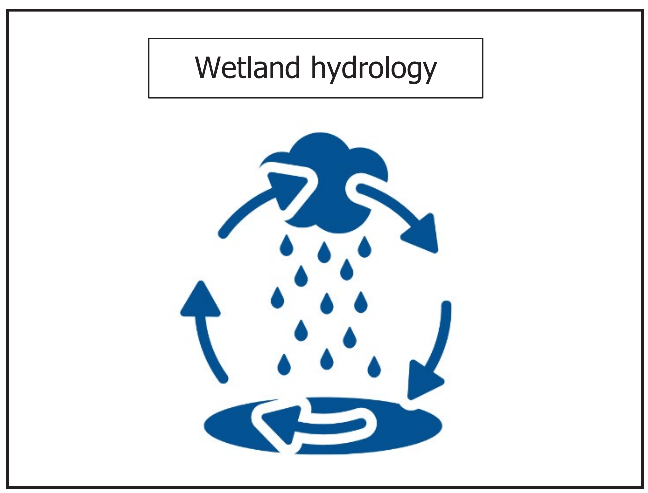

Turbidity

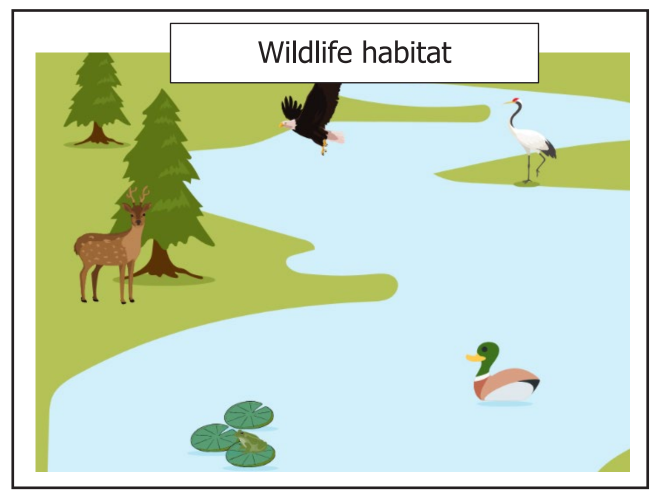

Vernal pools


Vertical flow constructed wetlands


Water pollution


Wet meadow


Wetland hydrology


Wildlife habitat

Appendix B

Additional Materials for Lesson Plan 3: Wetland Water Quality and Testing

These printable instructions can be used by students to follow along with and complete the Water Quality Testing of Various Liquids activity in the second phase of Lesson 3: Wetland Water Quality and Testing.

Wetland Water Quality and Testing

Activity 2: Water Quality Testing

Overview

Work in groups to test the water quality of several different water samples by carefully following the procedures below.

Safety

Use splash goggles and gloves. Tie back long hair. Follow correct procedures for handling glassware and chemicals. Dispose of waste in waste containers as instructed by teacher.

Materials

- "Clean" water sample
- "Polluted" water sample with detergent
- "Polluted" water sample with fertilizer
- "Polluted" water sample with organic matter
- "Unknown" water sample
- Tape and permanent marker for labeling
- LaMotte Earth Force test kit

Procedures

1. Obtain water samples from the teacher.
2. Label all test tubes with appropriate labels for water sample and specific test.
3. Observe the water samples designated to your group, and record observations. Note clarity, color, odor, and the presence of any suspended solids or surface film.
4. **To determine pH:**
    - 4. 1. Fill the pH test tube to 10 mL line.
    - 4. 2. Add one pH tablet in the tube and let dissolve. Record the color change with the pH color chart.
5. **To test for nitrates:** (follow the instructions below or as given by the teacher)
    - 5. 1. Fill the test tube to the 5 mL line with the sample.
    - 5. 2. Add one nitrate test tab from its blister pack. Cap and mix by inverting for two minutes to disintegrate the tablet. Wait five minutes for the pink color to develop.
    - 5. 3. Compare the color of the sample to the nitrate color chart and record as ppm nitrate. (Note: If the test gives results as ppm N, multiply by 4.4 to convert to nitrate ppm.)
6. **To test for phosphates:**
    - 6. 1. Fill the test tube to the 10 mL line with the sample.
    - 6. 2. Add one phosphate test tab from its blister pack. Cap and mix by inverting until the tablet has disintegrated. Wait five minutes for the blue color to develop. If the sample remains colorless, record the result as 0 ppm.
    - 6. 3. Compare the sample color to the phosphate color chart. Record result as ppm phosphate.
7. **To test for dissolved oxygen content:**
    - 7. 1. Fill the small test tube with water to the top.
    - 7. 2. Add one dissolved oxygen test tablet from its blister pack. Cap and make sure no air bubbles are present in the tube.
    - 7. 3. Mix by inverting until the tablet has disintegrated. Wait five minutes for the color to develop. Compare the sample color to the dissolved oxygen color chart. If the sample remains colorless, record the result as 0 ppm.
8. **To test for temperature:** Place the thermometer in the sample water and record the temperature in °C.
9. **To test for turbidity:** Place the Secchi disc in the water sample container and compare the appearance of the disc to the chart. Record the results.
10. Repeat the tests for all of your samples.

Lexington, KY 40506 Issued 01-2025