Algal Bloom Investigation Introductory Activity – Facilitation Guide (Grades 4th-12th)

Objective: The introductory activity will help students to better answer the primary algal bloom investigation question: "Based on physical, chemical and biological indicators, is an algal bloom likely to occur in your school's stream/pond?" Students work in small groups to learn what algal blooms are and to identify, graphically organize, and discuss their causes and effects.

Activity Components:

1. Algae Addition
2. Algae Interactions

Facilitation Instructions:

1. **Content Overview – By Grade Level**
   This is FYI only. Do not simply dictate this to students at the beginning. They are meant to discover and construct this information throughout the introductory activity. Additional content and definitions of terms are included in the Algae Interactions Poster Key and at the end of the facilitation guide.

   a. **Grades 4-5:** Like plants, algae grow best when they have plenty of light, nutrients and warm temperatures. Lowering the nutrients, temperature, and light they receive will decrease their growth. The flow and mixing of water helps control the light and nutrients available to them. The weather, location, nearby land uses, and shape/size of the water body also affect the algae. If conditions are favorable, algae can bloom. This means that they grow and reproduce quickly. Sometimes an algal bloom can become harmful. Then it is called a harmful algal bloom (HAB). Some of the algae that make up these blooms can harm organisms (plants, fish, birds, pets) that need the water for survival. Many water bodies are also used by humans for swimming, fishing, boating, and are treated and used for drinking water. Thus, it is important for scientists to study algae and monitor their growth to make sure that the ecosystem is in balance and that the algae are not affecting the stream/pond/lake in a negative way.

   b. **Grades 6-8:** Like plants, algae need light, nutrients and warm temperatures for optimal growth. Lowering nutrient, temperature, and light availability will reduce their growth. The flow rate/mixing of water help control the light and nutrients available. The weather, location, nearby land uses, and shape/size of the water body also affect the algae. If conditions are favorable, algae can bloom and/or cause a harmful algal bloom (HAB), which can harm organisms (plants, fish, birds, pets) that need the water for survival. Many water bodies are also used by humans for recreation (swimming, boating, fishing) and/or treated to use as drinking water. Thus, it is important for scientists to study algae and monitor their growth to make sure that the ecosystem is in balance and that the algae are not negatively impacting the stream/pond/lake and the organisms that rely upon the water for survival.

c. **High School:** Algae need light, nutrients and warm temperatures for optimal growth. Lowering nutrient, temperature, and light availability reduces the growth of most algal species. The flow rate and mixing of water help control the light and nutrients available. For example, high flows (like those associated with large rain events) mix the water and can bring large amounts of sediment and nutrients into the water body quickly through runoff. Increased nutrients can increase algal growth, but increased sediment can increase the turbidity (murkiness) of the water and decrease light availability. Some algal species are not well adapted to mixed (turbulent) conditions that can result from high flows. The weather, location, nearby land uses, and shape/size of the water body also affect the algae. In the Midwest, dry, hot summer months (July, August, September) often create the perfect conditions for algal growth. In addition, the use of fertilizers and pesticides on lawns, golf courses and agricultural fields can supply nutrients required for excessive algal growth. If conditions are favorable, algal growth and reproduction can increase greatly and cause an algal bloom or harmful algal bloom (HAB). HAB's result from the presence of algal species that produce toxins and other negative ecosystem effects, including algal scums on the water surface, taste and odor compounds, and so much biomass that once the algae start to die, bacteria decompose them and consume much of the dissolved oxygen needed by other organisms in the water. These HAB effects can harm organisms (plants, fish, birds, pets) that need the water for survival. Many water bodies are also used by humans for recreation and/or treated for drinking water. Thus, it is vital for scientists to research algal growth and HAB formation in order to better monitor and manage water resources by maintaining a balance in freshwater ecosystems.

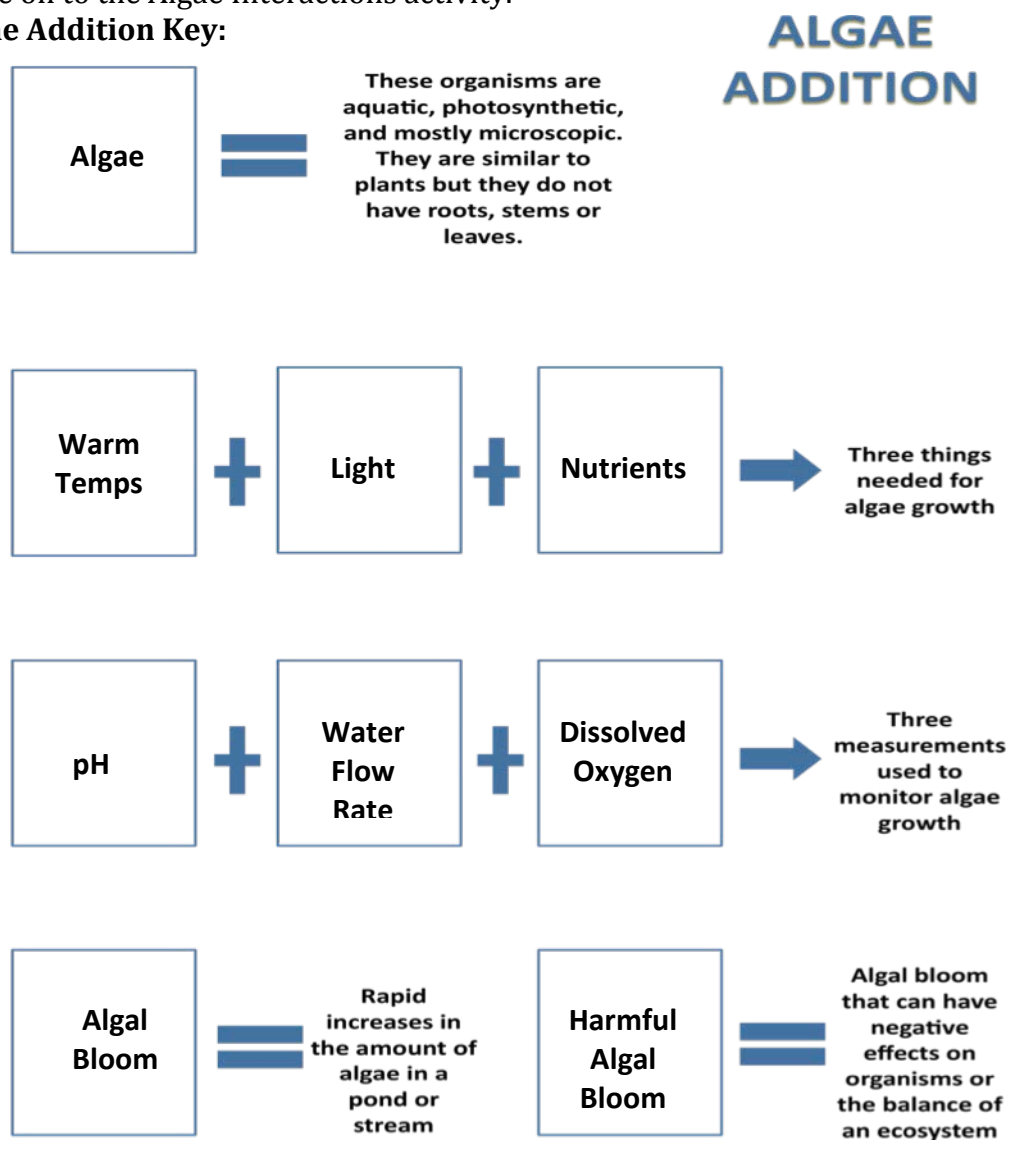
2. **Activity Introduction** – Begin by asking and briefly discussing the following questions: What are algae *(aquatic, photosynthetic organisms that often float at or below the water surface. Most are microscopic but some species can be quite large. They are different from plants because they lack true roots, stems and leaves)*? Where do they grow *(moist, freshwater or saltwater environments)*? Has anyone ever heard of an algal bloom? Then tell students that today they are going to learn what algae are, what conditions cause them to grow, and some of the effects algal blooms have on water quality.

3. **Algae Addition** – In order to begin understanding these concepts, students will work in groups of 3-4 to arrange nine different picture cards so that each is matched with its definition, factors needed for algal growth, or measurements taken to monitor algal growth.

   Instructions: Adjust instructions and facilitation based on the grade level and aptitude of the students.
   Using the Algae Addition poster and picture cards, students need to place each card in its corresponding square. The first team to have all 9 cards in the correct location/equation "wins." Start with each team's posters and cards facing down.

Use an extra Algae Addition poster to demonstrate the activity in front of the group. Tell students that 3 cards will match definitions; 3 cards will be what algae need for optimal growth; 3 cards will be things scientists can measure to monitor algal growth. Depending upon the group/grade level, more facilitation/explanation will be required, but try to let them figure out the equations on their own as teams before helping them. For the addition equations, the cards need to be in the proper equation, but do not need to be in a particular order. Students cannot look at the cards until you say, "Go!" When a team finishes, they must yell, "Algae Addition." If they have all the cards in the proper place, tell them good job and continue facilitating the other teams until they are finished. Afterwards, have the team that finished first come to the front and explain/discuss their equations. Facilitate the discussion and provide additional information, clarification, and examples as needed. During the discussion lead students into examples that they will use in the Algae Interactions activity. Have students remove their cards from the poster and move on to the Algae Interactions activity.

Algae Addition Key:



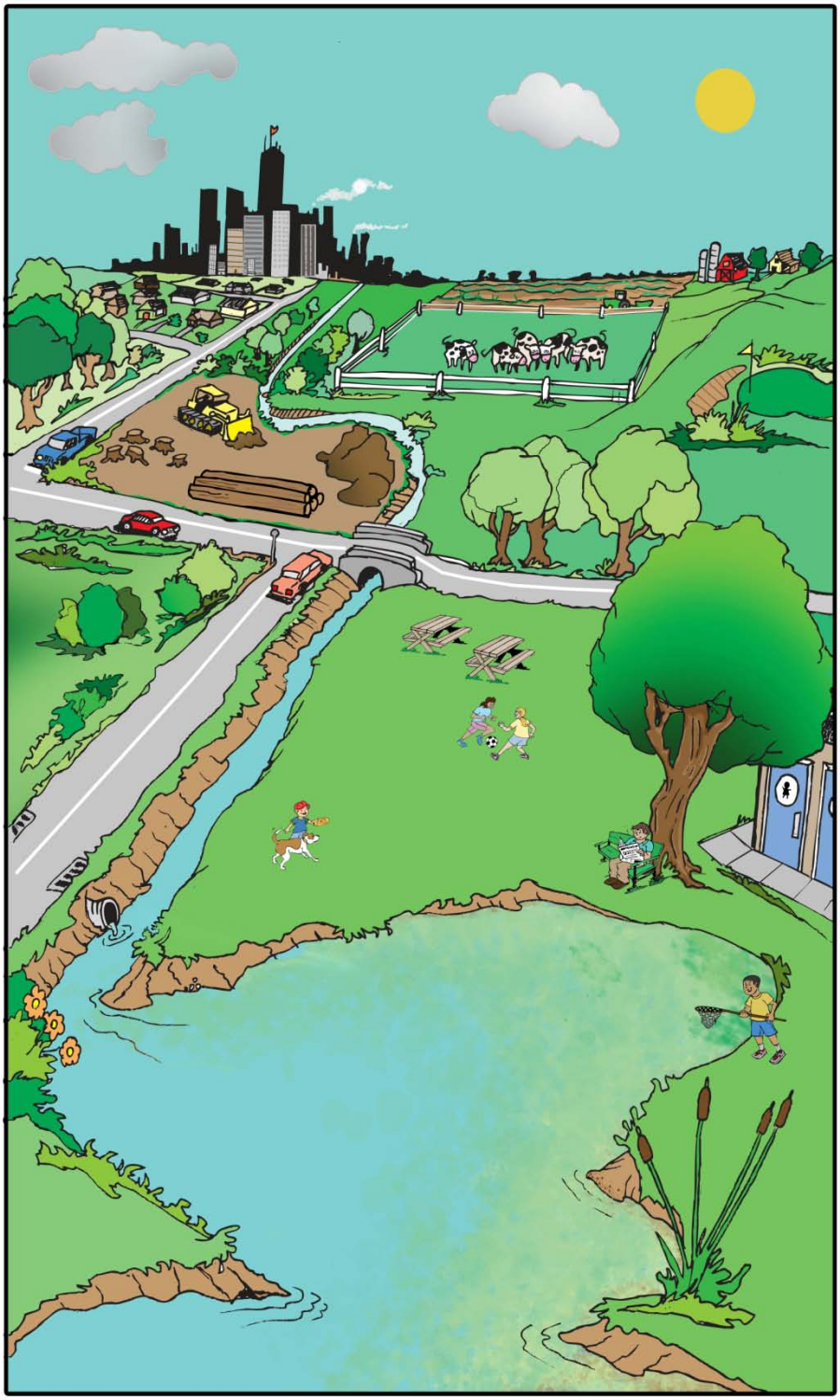
4. **Algae Interactions** – In their same groups, students will use color-coded chips to represent the algal growth and monitoring factors that they identified in Algae Addition. Using the Algae Interactions poster, students will place their colored chips on objects and/or activities that could impact algal growth and/or algal bloom formation.

   Instructions: Using the Algae Interactions poster, Algae Factors Key, and colored chips, students will work in their teams to identify objects and/or activities that could impact algal growth and/or algal bloom formation. This portion does not have a "winning" team. Instead, give them a time limit and specific instructions on what/how many things to identify (Refer to Grade Level Modifications at the end of the Facilitation Guide). Before time begins, lead the group through an example (i.e. Ask them to find something on the poster that would affect the light intensity reaching the algae in the pond → sun, clouds, etc.). Tell students to be creative; they can use their imaginations to identify factors that may not be explicit in the poster. Walk around and facilitate teams as needed. If they are having trouble, talk them through an example or help them with one of the harder ones (i.e. pH). *Specific examples of algae factor locations/objects are listed in the Algae Interactions Poster Key (below).* After time is up, have them put the chips down and as a whole group discuss where they put their chips. Go through each colored chip listed on the Algae Factors Key. Discussion questions could include the following:

   - Why did your team place its blue/yellow/green/etc. chip in that location? Did any of the other groups have the same colored chip in that location? Was it for the same reason?
   - Are there locations where your team has more than one color of chip? Explain.
   - Were there any algae factors that you couldn't find represented on the poster?

   As time allows, discuss thoughtful student responses and additional factors of importance—refer to those listed in the Algae Interactions Poster Key (below).

Algae Interactions Poster Key: Keep in mind that students may come up with ideas not listed here. This is fine as long as they can explain their reasoning.



- **YELLOW – Light intensity** refers to the amount of light that reaches the water surface at a given time. Light intensity is **affected by** a variety of weather conditions and the habitat that surrounds a water body. Trees and aquatic plants may block incoming light. Clouds, overcast conditions and seasonal changes also affect the amount of light that reaches the surface of the water.
  Poster examples: cloud cover, sunlight, shading by trees/shrubs around pond, sediment from runoff blocks/scatters light, leaf litter or debris in the pond

- **GREEN – Nutrients (Nitrates and Phosphates)** are important nutrients that allow aquatic plants and algae to grow. They are found naturally in the environment in small amounts, but too much can harm organisms that live in or drink the water. Excess nutrients enter the water from a variety of human-related activities. Nutrient levels are **affected by** soil type, vegetation, and seasonal conditions. Additional nutrients enter the water from animal manure, human waste, industrial discharges, and fertilizers/pesticides from golf courses and lawns. Land disturbances that move soil and increase erosion—such as clearing land for agriculture or construction—add phosphates to the environment.
  Poster examples: fertilizers from park/landscaping/golf course, erosion of sediment from construction site and channelized area, runoff through pipe from street/farm/city/suburb (entire watershed), dog (pet) waste, possible leaky holding tank from park restrooms, internal biological cycling of nutrients in the pond

- **RED – Water Temperature** measures how hot or cold the water is. Temperature is important because aquatic organisms can only live in certain temperature ranges and because temperature affects many other water quality factors. For example, colder water holds more oxygen than warmer water, and warmer water supports more species of algae. Water temperature is **affected by** air temperature, light intensity, water clarity (turbidity), vegetation cover, the type/depth/flow of the stream or pond, and groundwater or surface water in-flows.
  Poster examples: weather (cloud cover/overcast, sunshine), shading by trees/shrubs around pond, increased sedimentation (light scatter) generally increases water temperature, urban heat island, industrial warm water discharges

- **WHITE – DO (Dissolved Oxygen)** is the amount of oxygen in water; it is needed to support life in lakes and streams. If DO levels are too high or too low aquatic animals and plants can be harmed or die. When algae grow and reproduce (bloom) they produce oxygen. When plants and algae die and break down (decompose), they use up oxygen. DO levels are **affected by** water temperature (colder water holds more DO), flow rates and mixing, amounts of nutrients, chemical processes (photosynthesis, respiration, decomposition), altitude, depth, daily/seasonal cycles, and the amount of plants/algae in and around the water.

Poster examples: biological productivity (photosynthesis) in the pond, biological decomposition and respiration in pond (by bacteria) decreases DO, discharge/flow from pipe or other turbulence can increase DO, colder water holds more DO so any temperature-related objects/activities affect DO, water pollution (in general) leads to increased bacteria and decreased DO

- **BLUE – Flow rate** is the amount of fluid passing over a surface in a given amount of time. This is basically how fast the water is moving and is often measured in liters per second (L/s). Flow rates are **affected by** the size and shape of the water body, the elevation and geology of the surrounding area, amounts of precipitation and run off , wind, nearby or upstream land uses, and dams or other constructed features.
  Poster examples: channelization affects flow rate (especially during large rain events), shape of pond allows for algal accumulation in littoral (edge) zones, human activities (dams, recreation, bridges) affect flow, landscape appears to have downward slope

- **BLACK – pH** measures how acidic or basic (alkaline) the water is. pH values range from 0 to 14. Acids (battery acid or orange juice) have low pH. Bases (bleach or laundry detergent) have high pH. Liquids with pH values of 7 (drinking water) are neutral and are not acidic or alkaline. pH levels are **affected by** the source and amount of rain, urban runoff , and groundwater. The time of day, water temperature, algae/plants, soil, nearby or upstream land uses and discharges, urban and agricultural development, and chemical processes (photosynthesis and respiration) occurring in the water also affect the pH.
  Poster examples: almost any type of chemical pollution can alter the water's pH (i.e. gas and oil from cars/street runoff, industrial discharge, urbanization), construction site/soil pH/sedimentation, biological productivity and respiration in the pond

5. **Conclusion:** Using the cheat sheet, make sure that you have addressed each of the Introductory Activity Teaching Points:
   - Define algae, HAB, light intensity, nutrients, pH, DO, flow rate
   - Explain what conditions algae need to grow/thrive and how scientists use DO, pH, light, temp, flow, nitrates, phosphates to study/monitor algae
   - Discuss the causes of algal blooms and harmful algal blooms (HAB)
   - Complete the algae addition equations and discuss as a group
   - Used color-coded chips to identify/discuss algal bloom factors on the poster

   Then explain to students that they will use this information to complete their algal bloom investigation and predict whether or not and algal bloom is likely to occur in their school's stream or pond.

Additional Content/Definitions:

- **Algae** are aquatic, photosynthetic organisms that often float at or below the water surface. Most are microscopic but some species can be quite large. They are different from plants because they lack true roots, stems and leaves. Scientists study algae because they are an important part of the aquatic food web and they affect the chemical processes (photosynthesis, respiration, decomposition) occurring in ponds and streams.

- **Algal blooms** are rapid increases in the amount of algae in an aquatic system, such as a pond or stream. They occur naturally and often change the color of the water based on the amount and type of algae present. Some may be harmful and/or toxic depending upon the populations and amounts of algae present.

- **Harmful algal blooms** (HAB's) are algal blooms that have negative impacts on other organisms. HAB's can cause the release of toxins, such as Microcystin. These and other toxins can lead to sickness/death of birds, dogs and other animals, poor/unsafe water quality conditions, and human illness. Some algae species, especially blue-green algae, cause the water to taste and smell bad or have an unattractive color/appearance.

Modification Ideas:

- 4th-5th
  - Read over the algae addition definitions prior to letting the groups start arranging their cards. Discuss the difference between what algae need to grow/thrive (can relate it to plants) and what scientists can do to measure or monitor algae growth.
  - Students identify as many sources/effects without having to find one for each color; if they have trouble with certain colors, discuss options as a whole group; pH, DO and flow rate may be more difficult for them so facilitate as needed
  - After sharing out the poster's sources/effects, small groups discuss 1 way their own actions/behaviors could affect algae growth
- 6th-8th
  - Students must identify at least 2 sources/effects for each chip color; pH, DO and flow rate may be more difficult for them so facilitate as needed
  - After sharing out the poster's sources/effects, small groups discuss 1 way their own actions/behaviors could affect algae growth
- High School
  - Students must identify at least 3 sources/effects for each chip color
  - After sharing out the poster's sources/effects, small groups discuss 2 or more ways their own actions/behaviors could affect algae growth

DSE Algal Bloom Investigation: Resources

General Algal Bloom/Water Quality Resources:
http://www.glerl.noaa.gov/seagrant/GLWL/Algae/HAB/HABFAQ.html
http://www.nalms.org/nalmsnew/nalms.aspx?id=92&Sid=3
http://www.glerl.noaa.gov/res/Centers/HumanHealth/kids.html
http://www.phycotech.com/AlgaeTaxLinks.htm
http://waterwatchadelaide.net.au/
http://www.epa.gov/volunteer/stream/vms50.html
http://vis.iu.edu/Discover/Water/index.html

National Drinking Water Standards:
http://www.epa.gov/safewater/contaminants/index.html

Indiana Background Information:
http://www.in.gov/idem/algae/
http://www.cees.iupui.edu/Info/Press/Water_Resources/index.htm
http://www.cees.iupui.edu/research/water_resources/CIWRP/Algae_Information/Research.htm

Current Events:
http://www.theindychannel.com/news/14021434/detail.html
http://sports.espn.go.com/espn/print?id=3463937&type=Story&imagesPrint=off
http://www.ens-newswire.com/ens/aug2008/2008-08-06-091.asp
http://www.cees.iupui.edu/Info/Press/Water_Resources/index.htm

Image Resources:
http://www.bgsu.edu/departments/biology/facilities/algae_link.html
http://www.glerl.noaa.gov/seagrant/GLWL/Algae/Algae1.html
http://www.rbgsyd.nsw.gov.au/welcome_to_bgt/quick_links/hot_science_topics/australian_freshwater_algae2/algpic/cyanobacteria
http://www-cyanosite.bio.purdue.edu/

Video Resources:
http://www.theindychannel.com/news/14021434/detail.html
http://www.indianalakes.org/
http://www-cyanosite.bio.purdue.edu/

Curriculum Resources:

Environmental Inquiry: Authentic Scientific Research for High School Students
<http://ei.cornell.edu/watersheds>

Carlsen, William S., Trautmann, Nancy M., and the Environmental Inquiry Team. *Watershed Dynamic: Student Edition*.

Cornell Scientific Inquiry Series. National Science Teachers Association Press. Arlington, Virginia. 2004.

Eckhardt Slattery, Britt, et al. *Wow! The Wonders of Wetlands: An Educator's Guide*. Environmental Concern Inc. and The Watercourse. St. Michaels, Maryland and Bozeman, Montana. 2003.

Healthy Water Healthy People: Field Monitoring Guide. Project WET - Water Education for Teachers. Project WET International Foundation. Bozeman, Montana. 2003.

Healthy Water Healthy People: Water Quality Educators Guide. Project WET - Water Education for Teachers. Project WET International Foundation. Bozeman, Montana. 2003.

Project Wild Aquatic: K-12 Curriculum & Activity Guide. Project Wild and Council for Environmental Education. Houston, Texas. 2003.

Waterwatch Australia National Technical Manual. Waterwatch Australia Steering Committee. Australia Government, Department of the Environment and Heritage. <http://www.waterwatchadelaide.net.au/>. 2004.