Abiotic Components of a Freshwater System

Grade Level: Elementary, Middle School, High School
Ecological Concepts: **Abiotic**, Physical factors
Arizona Science Standards: Science as Inquiry; Life Science

Materials:
1) Pond, stream, or aquarium
2) Loupe or magnifying lenses *
3) Chemical tests *
a) pH
b) Dissolved oxygen (DO)
c) Phosphate
d) Nitrogen
4) Rulers
5) Air and water thermometers in °C *
6) Record keeping materials
7) Sampling cups *
8) Wear boots, aqua shoes or old sneakers
* May be borrowed from SCENE.

BACKGROUND
Water is a necessity for all life on this planet. Aquatic **ecosystems** can be ponds, streams, lakes or oceans. Freshwater ecosystems are usually divided into still water (ponds) and flowing water (streams). Some systems encompass both still and flowing water, such as a stream with deep pools.

A variety of organisms live in freshwater, some throughout their lives, others only for certain stages, usually as immatures, or juveniles. Even in the Sonoran Desert there is naturally occurring freshwater. There are rivers and streams that flow all year long, and others, called "ephemeral," flow only during wet seasons. Ponds and pools exist as well, usually ephemerally.

In functioning aquatic systems there is a variety of plant and animal life, the **biotic** part of the system. The **abiotic** component of freshwater systems is as important as the biotic. Water temperature, pH, phosphate and nitrogen levels, dissolved oxygen, and **substrate** composition are some of the abiotic factors to consider and measure. These must be within certain ranges for the system to be habitable for living organisms.

GUIDED INQUIRY
Observation/Exploration Period: Have students observe the water habitat using their eyes, **magnifying lenses**, **dip nets**, etc. (NOTE: Emphasize that they**DO NOT** drink the water. No open water is safe.) This is open observation time. Remind them to record their observations and any ideas or questions that come to mind. They can use words, drawings, charts; whatever they think is best for record keeping. They can categorize their findings (examples: water is cold/warm, clear/murky, plants are above/below water, strange-looking insects...) as they see fit.

Group Discussion and Question Period: Either have small groups discuss their observations and questions together first and then form one large group, or go immediately to one large group. Once in the large group, using the chalkboard or large pad of paper, record the major points that each small group has decided are characteristics of the aquatic system. Guide students to look for patterns among and between the different areas of the aquatic habitat, in particular the abiotic components they observed. As discussion continues, focus on one aspect of the abiotic features, such as water chemistry.

Some questions that might arise are: Does water chemistry vary in different parts of the system? How much oxygen is in the water? What other chemicals are in the water? Does water chemistry vary at different times of the day or in different seasons?

Important aspects of guided inquiry are encouraging students to generate multiple hypotheses, and letting students make decisions about what data are important and create their own data sheets. Keeping these ideas in mind, the sample in the box below illustrates how ONE OF MANY possible investigations around this topic might develop.

Sample Hypothesis: Let's use the question, "Does water chemistry vary at different times of the day or in different seasons?" The hypothesis could be, "If the chemistry of an aquatic system changes throughout the day and we measure the chemical components at different times of day, then we will discover those differences." Or, "Water chemistry changes throughout the day because changes in temperature change water chemistry."

Sample Experiment Design: The **independent variable** is time of day, morning versus afternoon/evening. The **dependent variable** is the value of the particular component of water chemistry being measured, for example, dissolved oxygen, phosphate, nitrogen, or pH. Since you will most likely be using only one body of water, it will not be possible to actually **replicate** the treatment groups. To do that, you would need multiple bodies of water, i.e., ponds. Instead, you will take at least three measurements for the same water component in the exact same place in the water. For example, measure the dissolved oxygen three times at the same place and same depth in the morning and then again in the afternoon/evening. By measuring at the same place and depth you will be **controlling** for these factors.

Note: Days with the largest changes in air temperature are the most likely to yield larger changes in water chemistry, but very hot days can deplete DO (dissolved oxygen) very quickly (hence fish kills), depending on the type of water body. Unfortunately, with an artificial, enclosed, pumped system the changes that would be seen in a natural system may not occur in the course of one day. Depending on the type of water system you have, you need to consider whether to run the experiment as above, in one day, or to take measurements in the same places but over a longer period of time to compare seasonal effects and changes.

Sample Prediction: Levels of dissolved oxygen, phosphate, nitrogen, and pH will change from morning to night.

Record Results: Using the test kit for water chemistry, measure the dissolved oxygen, phosphate, nitrogen, and pH levels and record the values for morning and afternoon or evening. If conducting this experiment over different seasons rather than at different times of day, try to conduct the tests at the same time of day, and record the values of the same abiotic components each time.

Sample Analysis of Data and Presentation: Make a separate **bar graph** for each water chemical, with the time of day listed on the horizontal axis and the raw number values on the vertical axis. For students who can divide, calculate the **average** water chemical value for each time period. Graph the average number on the vertical axis. If the water chemistry is tracked over seasons, make a **line graph** with time on the x-axis and averages on the y-axis.

Discussion: Was your hypothesis supported? If yes, go on to test other hypotheses. If not, why not? What did happen? Why? This is a great opportunity to revise your hypothesis and do another test.

MORE:
(1) Elementary:
(a) Measure water depth and temperature in various places in the pond. Take several temperatures in the same place at the same depth and average the results. Compare to temperature averages from other sites in the pond. Measure air temperatures in shade and sun and see how these values compare to water temperatures.
(b) Take same measurements in an artificial pond and a natural pond; compare. Try to compare ponds that

are similar in size, depth, and type of location (i.e., shaded, not shaded).

(2) Middle School:
(a) Find the **mean**, **median**, **mode** and **range** of the data.
(b) If the aquatic system is a stream, determine the **water velocity** (V) in meters per second. Calculate V in different parts of the system. Examine possible**correlations** with other abiotic or biotic features (**See Biotic Components of Ponds activity**).

(3) High School:
(a) Calculate the **variance** and **standard deviation** of the averaged data.
(b) Perform a **T-test** comparing chemistry in two different parts of the system. (T-test is a standard statistics test comparing **means** of two treatment groups). Perform an **ANOVA** when comparing three or more treatment groups.
(c) Test for a **correlation** between two variables, e.g., dissolved oxygen levels and abundance of aquatic insects (**See Biotic Components of Ponds activity**). Draw a **scatter plot** and calculate the sample **correlation coefficients**.
(d) Measure water depth and width, use to calculate **stream flow or discharge, Q**.

References:
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Canterbury Environmental Education Centre, UK. Website of pond activities and organism identification.**www.naturegrid.org.uk/pondexplorer/pond1.html**

Institute for Inquiry Web Site. "Created in response to widespread interest in inquiry-based science instruction, the Exploratorium Institute for Inquiry provides workshops, programs, on-line support, and an intellectual community of practice which afford science reform educators a deep and rich experience of how inquiry learning looks and feels." **www.exploratorium.edu/IFI**