Background Information: Water Quality

# Introduction to water quality parameters

Nutrients are chemical substances found in every living thing on Earth, and they are necessary for everything to live. They are used in every process within an organism’s body, including growing, repairing, breathing, reproducing, eating, etc.

Autotrophs are organisms that make their own food. Heterotrophs can get their food (in the form of nutrients) from multiple sources but cannot make it themselves. Plants and other autotrophs (like some bacteria) absorb nutrients from soil and water. They can then use these nutrients to synthesize more complex molecules needed for life, such as Deoxyribonucleic Acids (DNA), proteins, carbohydrates, or Adenosine Triphosphate (ATP). Carbon, hydrogen, and oxygen are key elements for all living things. Other required nutrients include nitrogen, phosphorous, potassium, calcium, magnesium, and sulfur (National Geographic, n.d.).

Humans are a natural part of the environment. However, humans are smart and powerful animals, which can lead us to have enormous impacts on ecosystems. With most anthropogenically derived environmental issues, the problem does not come from humans in general, it comes from humans speeding up natural environmental cycles and throwing the system out of equilibrium.

For example, we know that nutrients naturally cycle through the environment, between rocks, soils, bacteria, plants, animals, and the atmosphere. Because nutrients are so important for life, humans will sometimes manipulate those natural cycles to speed up the rate at which things can grow. For instance, we can take multi-vitamins to ensure that certain nutrients get taken up into our bloodstream to keep our body processes working optimally. We can also remove nutrients from rocks at rates that are much greater than typical environmental weathering and turn those nutrients into fertilizers to apply to crops to make them produce large harvests every year.

Although living things use nutrients for every process, they also shed them if they are not in a form they can use or if they are in excess. You might have heard about this with regards to vitamin absorption – if your body can’t absorb it fast enough or if you take too much, it will often pass right through your system through your urine. Urine and feces from animals typically contain a lot of nutrients, which can make those resources excellent fertilizers. Of course, these nutrients can be packaged in different molecules and different forms, and only the right form in the right amount can be used by any given living thing. The same form of nutrient (a bag of plant fertilizer, for example) can be super useful to some organisms (plants), inert or nonreactive for others (spiders) and toxic to others (humans).

# Baseline water quality values

We will measure three important water quality parameters in this activity.

***Turbidity:*** Turbidity refers to how clear or how cloudy the water, which is indicative of the concentration of suspended solids. Clear water has a low turbidity level and cloudy or muddy water has a high turbidity level. Turbidity level in natural waters can vary really broadly depending on the natural characteristics and other environmental factors. High turbidity can indicate very turbulent water, surface water coming into a water body (and often bringing sediments with it), or pollution. Particles that cause turbidity can often carry nutrients, bacteria, or other contaminants into a water body. Therefore, although turbidity itself isn’t necessarily a bad thing, it can be an easy measure that can indicate other environmental problems.

***Phosphorous:*** Even a modest increase in phosphorous has the potential to set off a chain of undesirable events in a stream including accelerated plant growth, algae blooms, low dissolved oxygen and the death of certain fish and other aquatic life. Phosphorous is found naturally in water from soil and rock sources, but can also be released by sewage, animal waste, and agricultural (fertilizer) run-off.

Pure, “elemental” phosphorous (P) is rare. In nature, phosphorous typically exists as phosphate (PO43-), sometimes with some hydrogen ions attached (HPO42-, H2PO4-, H3PO4). Orthophosphate is a chemistry term referring to the phosphate molecule by itself, regardless of hydrogens. The orthophosphate test measures dissolved and suspended orthophosphate. In this experiment, you will divide the phosphate value by 3 to obtain mg/L phosphorous.

***Nitrates:*** Nitrates occur in water as the end-product in the biological breakdown of organic nitrogen, being produced through the oxidation of ammonia. Although not particularly toxic to fish, excess nitrates in the water is often used as an indicator of poor water quality and can also cause algal blooms.

Nitrate is measured in parts per million (ppm) or milligrams per liter (mg/L; 1 ppm = 1 mg/L). Nitrate occurs naturally in surface and groundwater at concentrations up to 1-2 mg/L. The safe drinking water standard for nitrate is 10 mg/L, but levels above 2 ppm may indicate contamination from sewage or agriculture (fertilizer) run-off. Results from this test are given as “X mg/L nitrate-nitrogen (NO3-N).”

***pH:*** pH is an expression of hydrogen ion concentration in water. Specifically, the negative logarithm of hydrogen ion (H+) concentration (mol/L). This indicates acidity or basicity on a scale of 0 (highly acidic) to 14 (highly basic). A pH of 7 indicates neutrality. The EPA states, “pH affects chemical and biological processes in water. It is one of the most important environmental factors limiting species distribution in aquatic habitats. Different species flourish within different ranges of pH, with the optima for most aquatic organisms falling between 6.5-8.0. Even small changes in pH can shift community composition in streams. This is because pH alters the chemical state of many pollutants (e.g. copper, ammonia), changing their solubility, transport, and bioavailability. This can increase exposure to and toxicity of metals and nutrients to aquatic plants and animals.” ([US EPA CADDIS Volume 2 website](https://www.epa.gov/caddis-vol2/ph#:~:text=Different%20species%20flourish%20within%20different%20ranges%20of%20pH%2C,freshwater%20suggest%20a%20range%20of%206.5%20to%209.).)

***Dissolved Oxygen:*** Dissolved oxygen is the amount of oxygen present in water. Water bodies receive oxygen from the atmosphere and from aquatic plants and other photosynthesizers. Swift moving water, such as from a stream, or turbulent water, such as from waves, dissolves more oxygen than still water (such as from a lake or pond). DO can be measured as a percent of the saturation (% DO) relative to water at sea level, or it can be measured in milligrams per liter (mg/L) for a “net” amount of oxygen in the water, based on temperature and salinity. DO can be affected by temperature (warmer water holds less oxygen than colder water), salinity (seawater holds less oxygen than freshwater), and barometric pressure (lower pressure environments hold less oxygen, such as high altitudes). Every organism has its own DO tolerance range. But generally, natural waters with DO levels below 3 mg/L are concerning, and levels below 1 mg/L are considered hypoxic and tend to be devoid of life. Because DO is so fickle and can change so quickly, it is only measured out in the field at the water source, and never from a sample bottle.



Water quality parameters can vary a lot from site to site. These variations can be based on inputs and conditions of the system from natural and anthropogenic sources. As a result, it can be very difficult to determine the “good” or “right” values for a particular parameter.

The US EPA has developed criteria for specific ecoregions that aim to represent the conditions of surface water that are minimally impacted by human activities and that are protective of life and recreational uses. These criteria differ by region due to things like geology and hydrology. The criteria for two ecoregions are shown below. Additional criteria and reports on how these criteria are developed can be found here: <https://www.epa.gov/nutrient-policy-data/ecoregional-nutrient-criteria-rivers-and-streams> or <https://www.epa.gov/national-aquatic-resource-surveys/indicators-used-national-aquatic-resource-surveys>.

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| --- | --- | --- |
| Parameter | Ecoregion IIWestern Forested Mountains | Ecoregion IIIXeric West |
| Total phosphorous (µg/L) | 3.0-32.5 | 10-55 |
| Total nitrogen (mg/L) | 0.0-0.53  | 0.22-0.90 |
| Turbidity (NTU) | 0.25-5.5 | 1.93-5.13 |
| pH | 6.5-9.0 (consistency is more important than actual value) |
| Dissolved Oxygen (mg/L) | < 3 = water of concern; < 1 = hypoxic, devoid of lifeotherwise, depends on specific organism tolerance |

Background Information: Photovoice

"*We believe photography is more than just light, beautiful pictures, or perfect proportions. It is also a vehicle for real change*." – [Cristina Mittermeier](https://cristinamittermeier.com/)

# Overview

[PhotoVoice](https://photovoice.org/) is a qualitative research method that empowers positive social change through the ethical use of photography. A photograph is the easiest way to share your experiences and raise awareness about global issues to a general audience (Blackman & Fairey, 2007).

You will use photography to investigate intersectional issues related to water systems (e.g., water governance, security, pollution, etc.). This activity aims to challenge your perspective about our planet, relationship with its living and nonliving entities, and connection with water.

# Photography

You do not need professional equipment or extensive knowledge of photography to complete this project. Most smartphones have high-quality cameras you can use.

When photographing, consider these basic elements:

* Subject – What do you want to convey to the viewer?
* Composition – Notice the depth of field, foreground, background, negative space, filled space, shapes, contrast, color, and viewpoint.
* Light – Do you want to use natural light, flash, shadows?

**Ethics:** Photography should capture candid moments of reality, do not use Instagram or Snapchat filters. Respect the privacy and property of others and always obtain consent before photographing others. Minimize disturbances when photographing natural habitats and wildlife.

# Group Discussion

All photographs will answer the research question: ***What does water mean to you?***

Use the following guiding questions to brainstorm:

* How do you use water?
* Where does your water come from?
* What elements of natural and anthropogenic water systems are around you?

# Individual ReflectionQR code for this padlet

Upload an **original, creative, and contemporary photograph** to Padlet (<https://tinyurl.com/riverphoto23>). Plagiarized pictures (i.e., Google images) are not allowed. For your reflection, answer the following questions:

1. **What do you see?** – Provide a literal and detailed description of the image.
2. **What issue related to water systems are you highlighting?** – Provide evidence about the issue's scientific, cultural, and/or historical significance.
3. **How does the issue connect to your experiences?** – Share anecdotal evidence and/or personal insights about the issue's significance.

# Rubric

Your photograph and reflection will be scored with this rubric.

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| --- | --- | --- | --- |
| Criteria | **Excellent (1 pt)** | **Satisfactory (0.5 pts)** | **Unsatisfactory (0 pts)** |
| Photograph | Photograph shows creativity and thought. | Photograph is unoriginal (looks like a stock image). | Does not include a photograph or photograph is plagiarized. \*If the photo is plagiarized, you will receive a 0% on the assignment. |
| Question 1 | Provides a literal description of the photograph; response is detailed. | Provides a literal description of the photograph; response is vague. | Does not provide a literal description of the photograph (i.e., interprets image). |
| Question 2 | Provides a detailed description of an issue related to water systems; demonstrates an understanding of real-world connections; response is detailed. | Attempts to describe an issue related to water systems; real-world connections are not logical; response is vague. | Does not describe an issue related to water systems. |
| Question 3 | Relates photograph to personal experiences; demonstrates an understanding of real-world connections; response is detailed. | Attempts to relate photograph to personal experiences; real-world connections are not logical; response is vague. | Does not relate photograph to personal experiences. |