PAR Attenuation in Water

Figure 1 Sunlight attenuating through water, reaching aquatic life

The process of photosynthesis involves the use of light energy to convert carbon dioxide and water into sugar, oxygen, and other organic compounds. In aquatic ecosystems, the amount of light that penetrates the water column determines how much energy is available for algae and plants to perform photosynthesis. As light passes through the water column, its intensity decreases, otherwise known as attenuation. Because of this light attenuation, as water depth increases, less energy is available for plants to perform photosynthesis.

Light attenuation can be affected by many factors including chemical compounds, suspended solids, and even plankton. Nutrient rich (eutrophic) bodies of water tend to have a much lower attenuation rate than bodies of water that are low in nutrients (oligotrophic). In other words, the clearer the water, the farther the light can penetrate the water column.

The most common way to measure light attenuation and turbidity is to use a Secchi disk. The disk is lowered into the water column until it is no longer visible. While this is an easy way to observe light attenuation, it can be open to subjective interpretation. To determine the amount of light available for photosynthesis at different depths, a sensor that measures photosynthetically active radiation, such as the Go Direct® PAR Sensor, should be used with, or instead of, a Secchi disk.

Objective

Use a PAR sensor to measure the amount of photosynthetically active radiation at different depths in a body of water.

Materials

- ☐ Chromebook™, computer, or mobile device
- ☐ Vernier Graphical Analysis® app
- ☐ Vernier Go Direct® PAR Sensor
- ☐ Secchi disk (attached to a cable or tape marked in meters)

Procedure

Figure 2 Go Direct PAR Sensor

1. Connect your PAR sensor via Bluetooth® wireless technology or USB.
   Note: The PAR sensor head should be attached to the top of a Secchi disk with a counter weight on the opposite side so the disk stays horizontal in the water column. Do not allow the sensor box to contact the water.

   If using Bluetooth, follow these steps:

   a. Launch Graphical Analysis, and click **Sensor Data Collection**.

   b. Find your PAR Sensor in the list of available devices and click **Connect**.
   Tips
   - The ID is located on the label on the sensor box.
   - Ensure the PAR sensor is powered on (red blinking LED) and that Bluetooth is enabled on your device.

   c. Click **Done**.

2. Set up the data-collection mode.

   a. Click Mode to open Data Collection Settings.

   b. Change Mode to Events with Entry.

   c. Enter **Depth** as the Event Name and **m** as the Units. Click **Done**.

3. Click or tap Collect to start data collection.

4. Measure the PAR value at the water line.

   a. Start at the top of the water line or at 0 m depth. In other words, make sure that the PAR sensor is just underneath the water surface.
   Important
   - Always maintain a solid grip on the cables and Secchi line.
   - Do not support the cables by holding the sensor box of the PAR sensor; the sensor could disconnect from the sensor box and sink to the bottom of the lake.
   - Do not allow the sensor box to contact the water.

   b. Monitor the readings. When the readings have stabilized, click **Keep**.

   c. Enter **0** for the depth in meters, and then click **Keep Point**.

5. Measure the PAR value at increasing depths.
    a. Using the calibrated line on the Secchi disk, lower the disk by 0.5 m.
    b. When the readings have stabilized, click **Keep**.
    c. Enter the depth of the PAR sensor in meters, and then click **Keep Point**.
    d. Repeat this step until you reach 4 m.
    e. After keeping the PAR value at 4 m, stop data collection.
    f. (Optional) Save the file as directed by your instructor.

Questions

1. How did the PAR levels change as the depth increased?
2. Which range showed the greatest attenuation of light? Which range showed the least attenuation of light?
3. How does attenuation of light relate to growth of photosynthetic organisms?
4. Based on your results, at what depths would you expect to find most of the aquatic life?

Extensions

1. Further analyze data by applying an inverse curve fit.
2. Analyze seasonal effects on light attenuation levels.
3. Analyze the light attenuation rates at different locations either within the same body of water or at different ones.

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1. Vernier Graphical Analysis® app is required for data collection. Download the latest version at www.vernier.com/ga
2. Go Direct® PAR Sensors can be connected via Bluetooth® wireless connection or USB. For additional information, see the booklet that shipped with your sensor(s) or visit
    - Getting started: www.vernier.com/start-go-direct
    - Collecting data with a PAR sensor, including troubleshooting: https://www.vernier.com/manuals/gdx-par/
3. Students should always wear proper flotation equipment when in or around water.
4. To prevent water damage, it is best to store all probes and electronic equipment in plastic bags or containers when not in use.
5. The sensor head of the PAR sensor can be submerged up to the black electronic box. This is approximately 5 m.
6. When measuring PAR at different depths in a lake or pond, it is best to choose a sampling site as far from shore as possible. This will generally require a boat or other form of floating vessel to reach the site. You can also use a floating dock or pier if needed, provided that the water depth is greater than 5 m at your location.
7. To ensure the PAR sensor stays level and in the correct orientation for depth studies, it is advised that it be attached to a stable object. A Secchi disk works well as it can be submersed and the PAR Sensor can be attached to it with the lens of the sensor pointing upwards.
8. If using a Secchi disk, the PAR sensor should be placed such that it is counterbalanced with another object such as a rubber stopper to minimize any tilting of the disk when it is lowered into the water by rope. The submersible portion of the PAR Sensor and cable can then be attached to the Secchi disk rope, which is already marked off in 0.5 m intervals. **Note**: The use of the Extra-Long Temperature Probe is a recommended extension of this activity, and it can be used as the counterbalance on the Secchi disk.
9. If you have a limited number of PAR sensors or devices (e.g., laptops or mobile devices), you may want your students to record the data in a data table in a lab notebook.

Sample Data

Table 1	
Depth (m)	PPFD (μmol m^{-2} s^{-1})
0	271
0.5	113
1.0	64
1.5	38
2.0	28
2.5	21
3.0	14

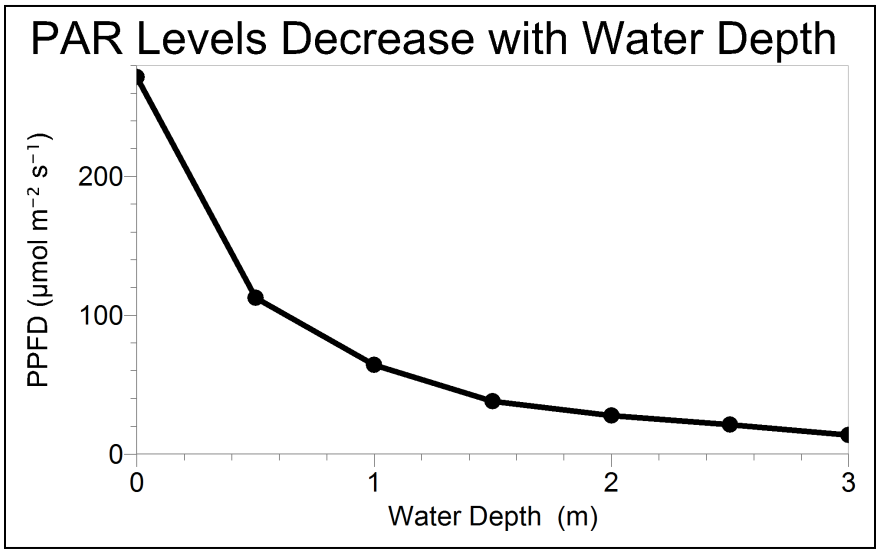

Figure 1 Sample data showing PAR decreasing as water depth increases

Answers to Questions

1. Answers will vary. Generally as the depth increases the PAR will decrease.
2. Answers will vary. Typically the greatest attenuation will occur in the first meter while the least attenuation will occur in the last meter measured.
3. Since the amount of PAR influences photosynthesis, and therefore plant life, plants will grow better when there are higher levels of PAR.
4. Most aquatic life will be found in the littoral and limnetic zones, which correspond to the top 10 m of the lake.